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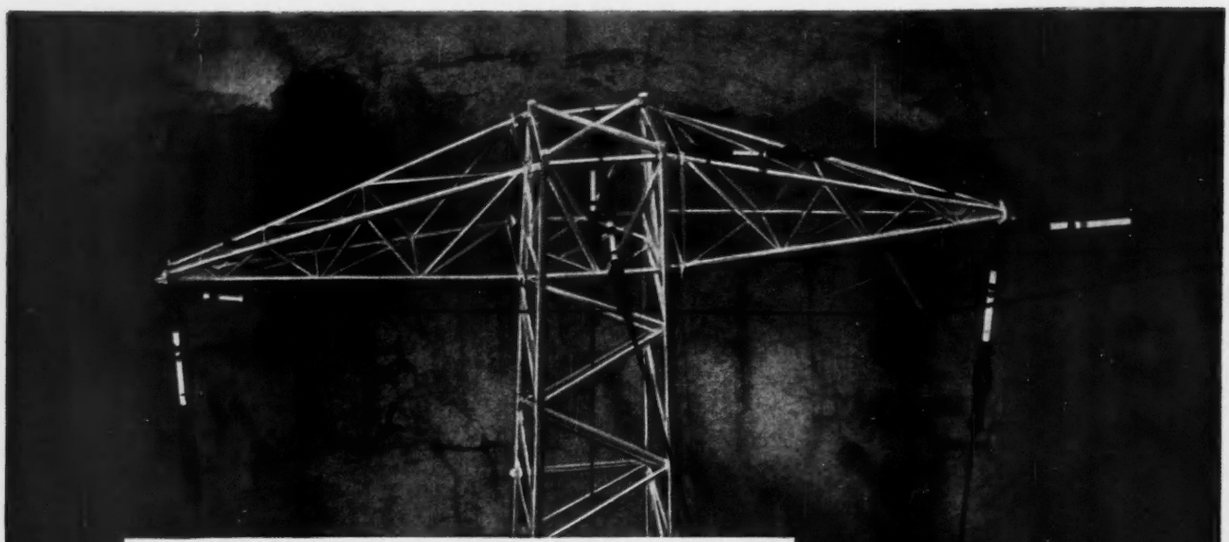

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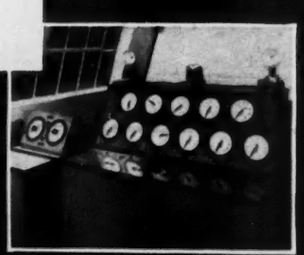
Basically, the device within the Pullmeter transmits to a remote indicator the changes of dimensions of a few thousandths of an inch and is therefore useful in many other aspects of research where small dimensional changes are to be measured.

Right: A Pullmeter. Below right: Load and deflection indicators



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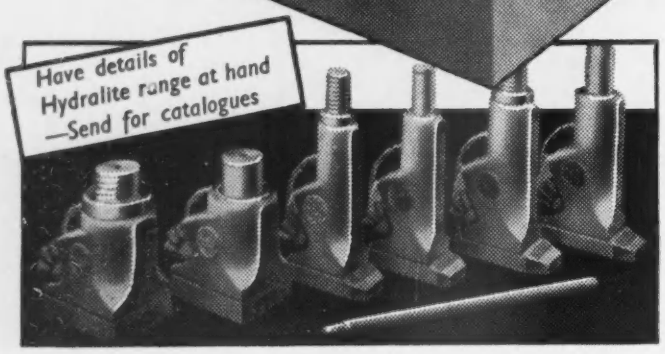

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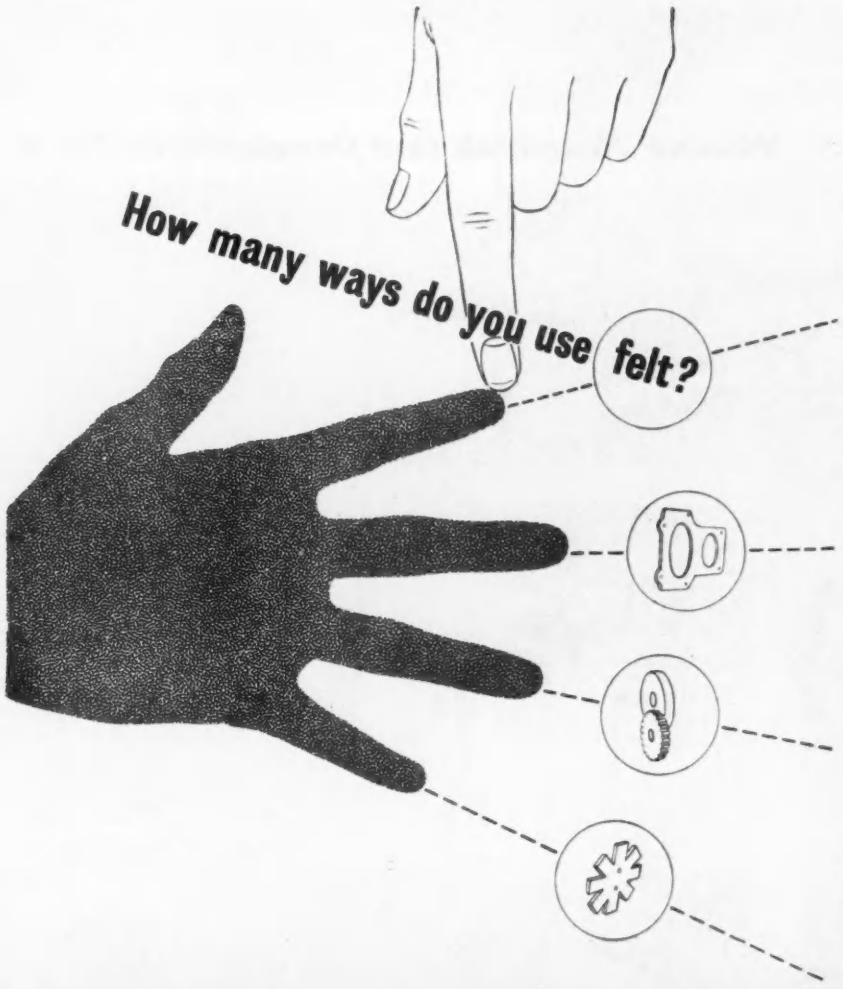

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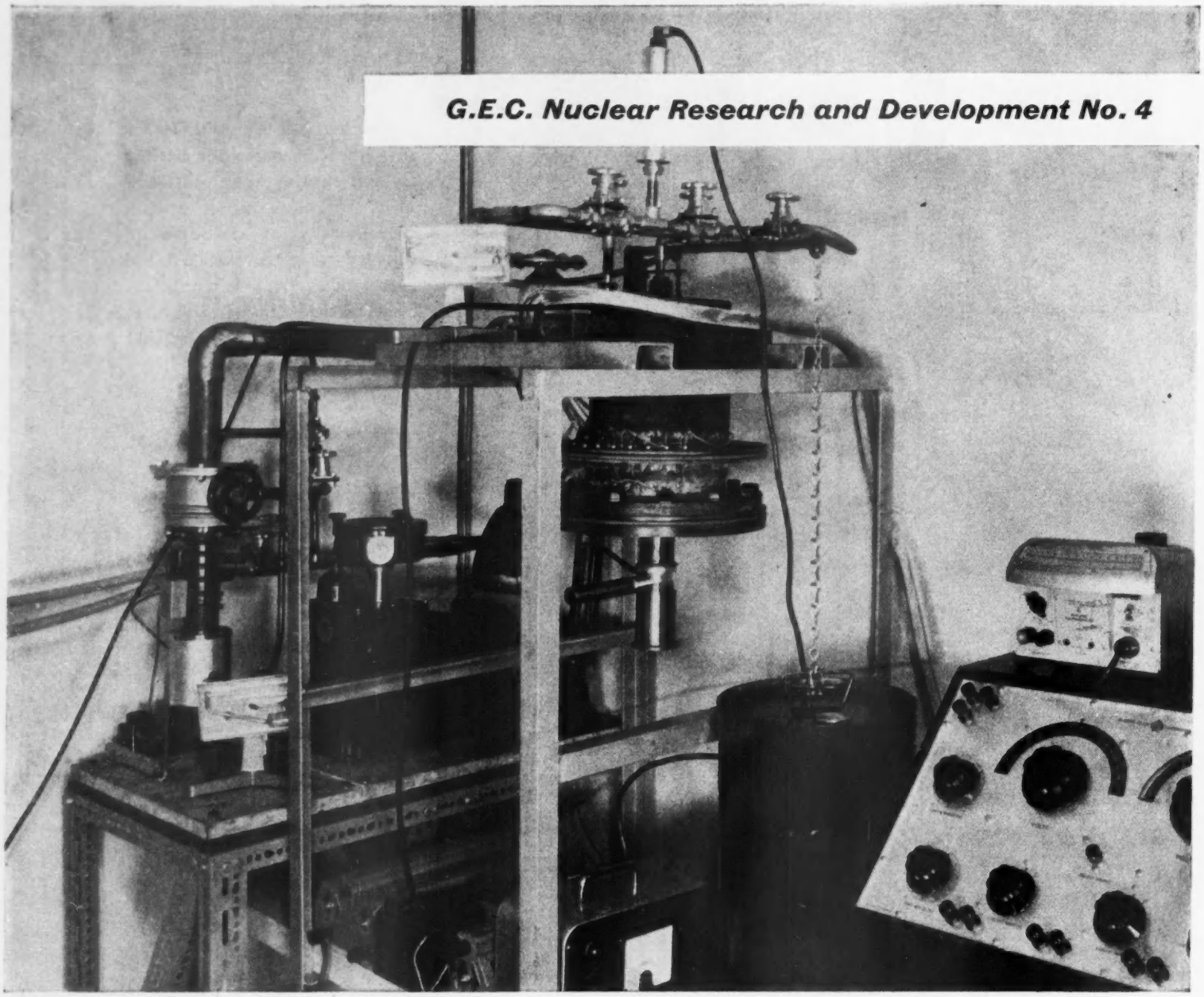

uranium-to-can heat transfer

In a nuclear power reactor metallurgical considerations impose a limit on the temperatures that can be allowed in the uranium fuel rods. At the same time it is essential for efficient heat transfer to the gas that the can should be as hot as possible. It is thus necessary to determine the temperature drop that will occur between the centre and the surface of a fuel element.

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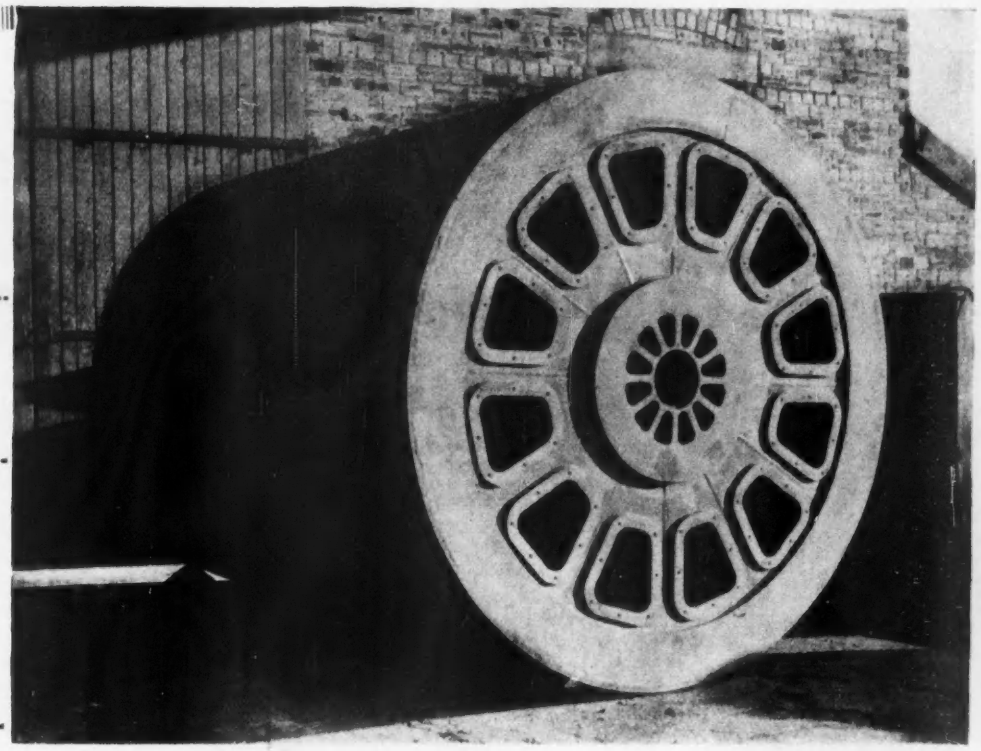

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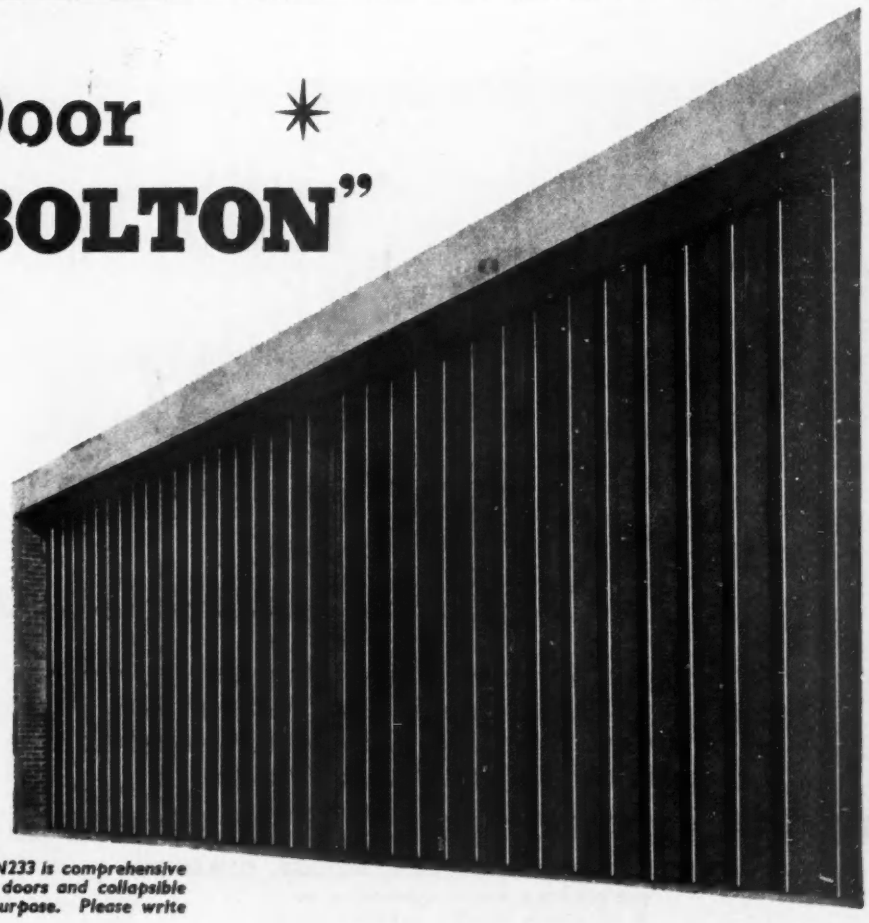

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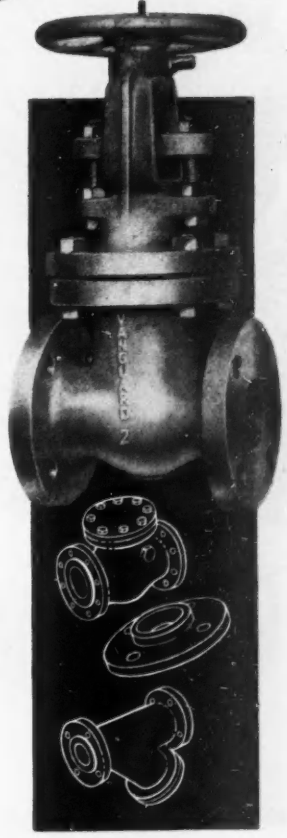

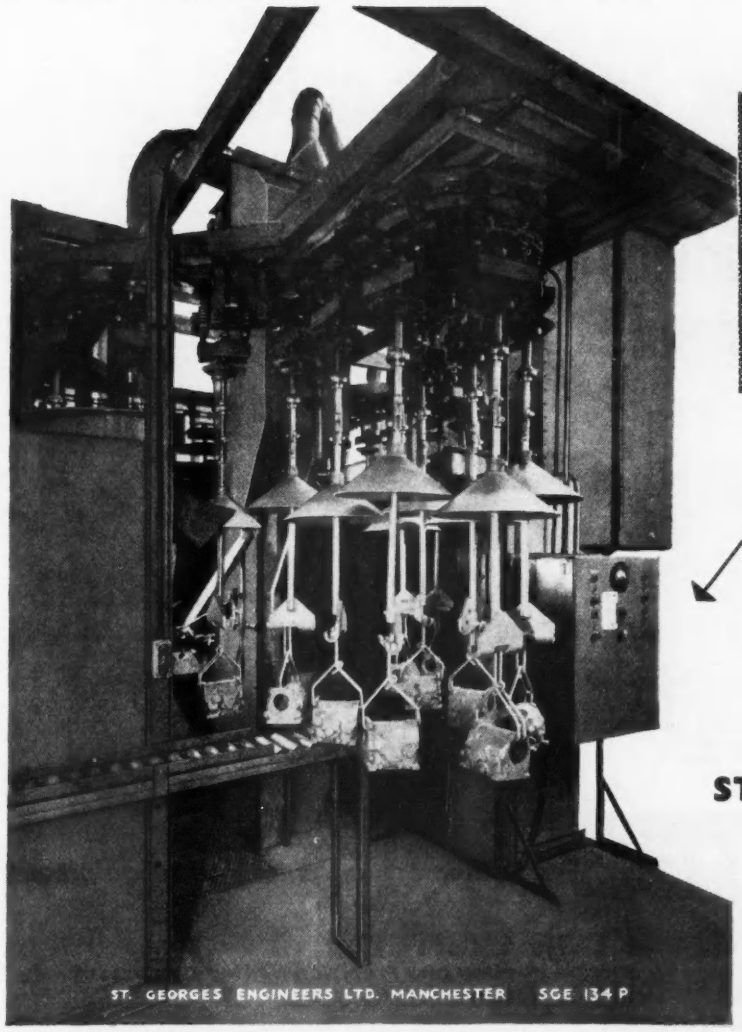

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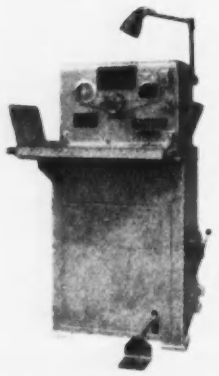

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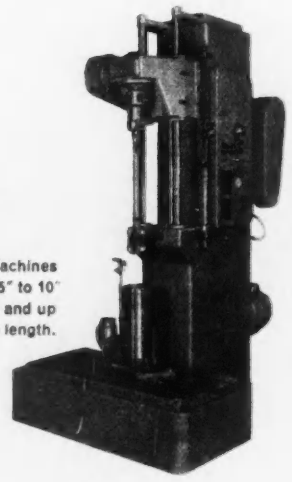

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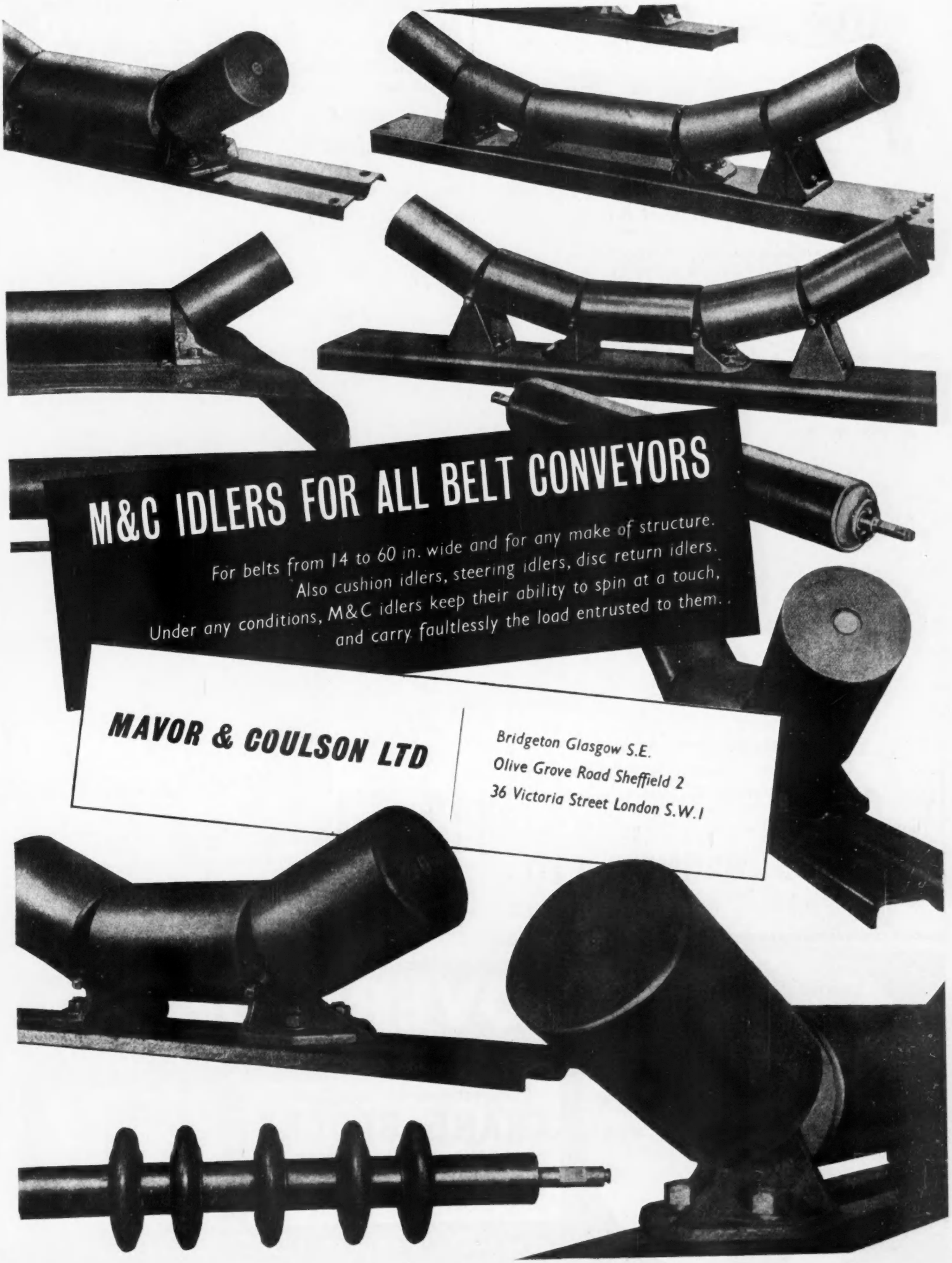

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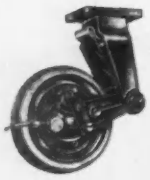

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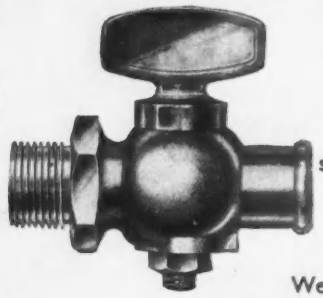

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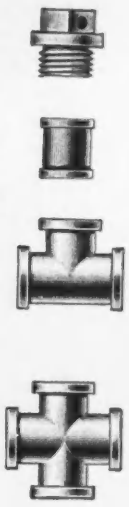

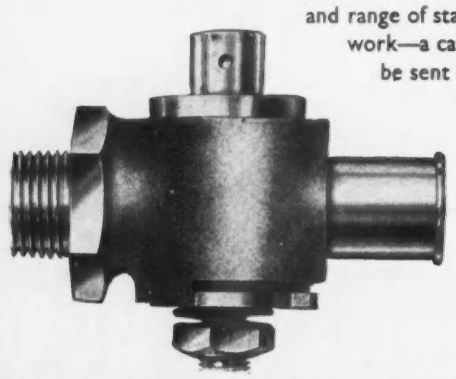

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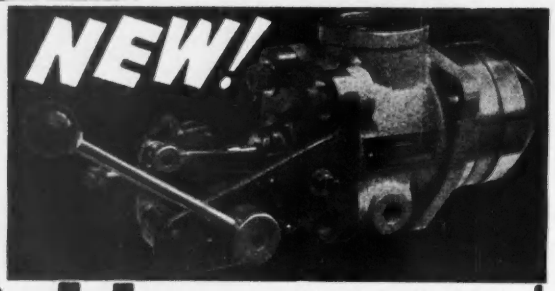

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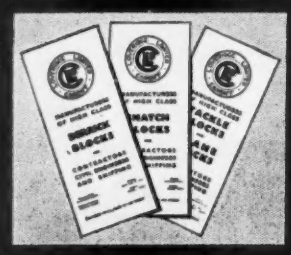

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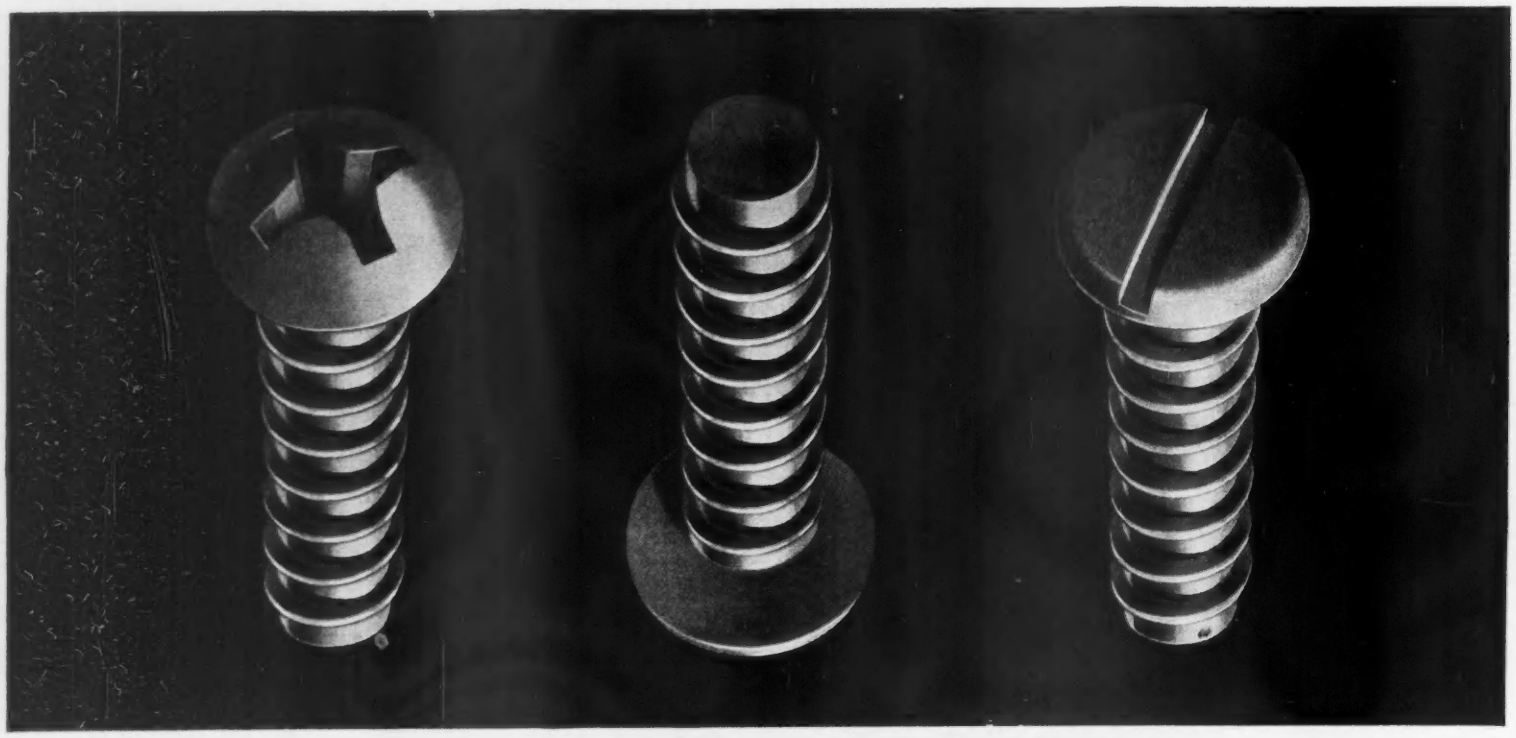

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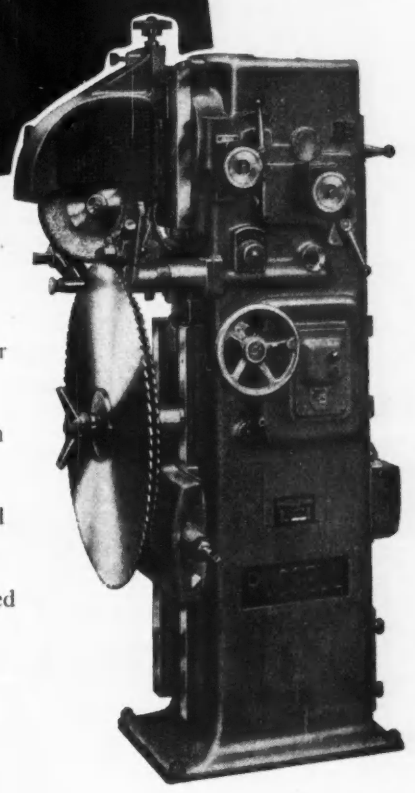

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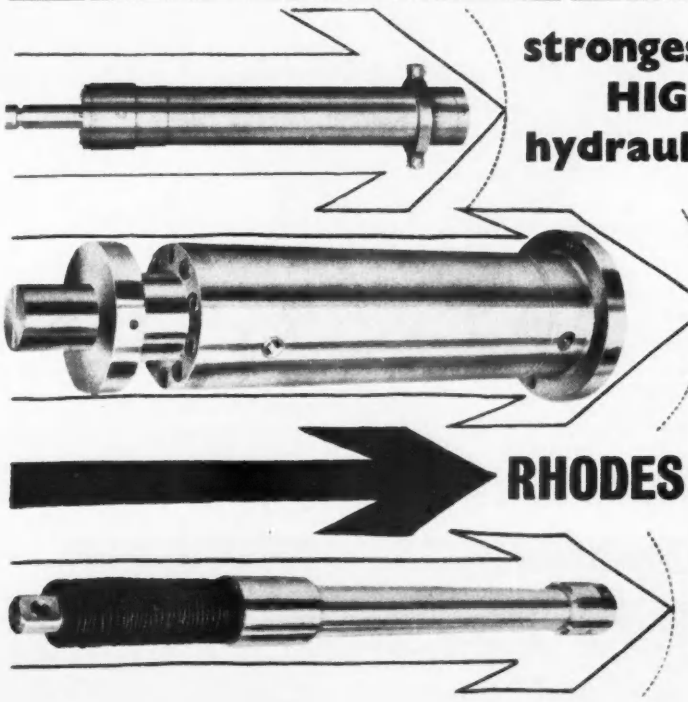

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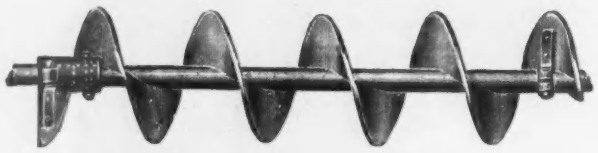

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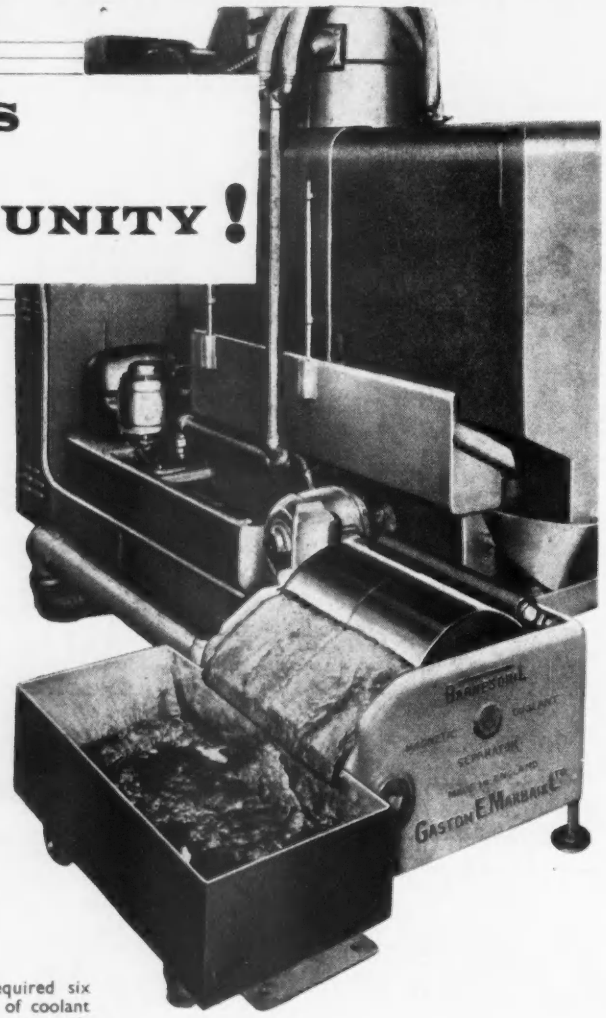

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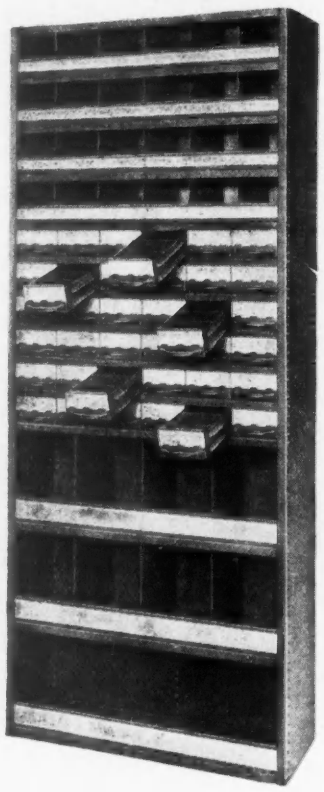

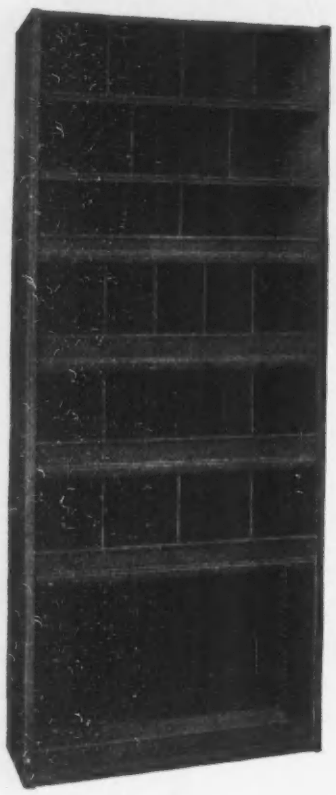

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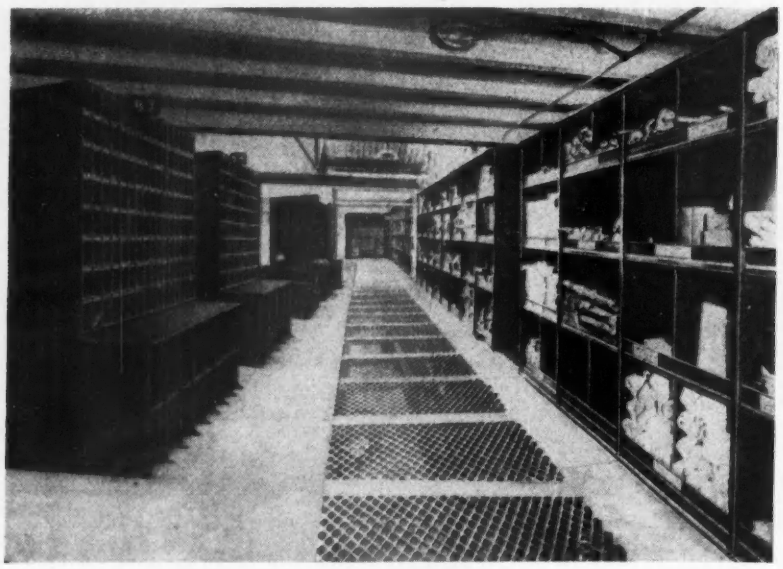

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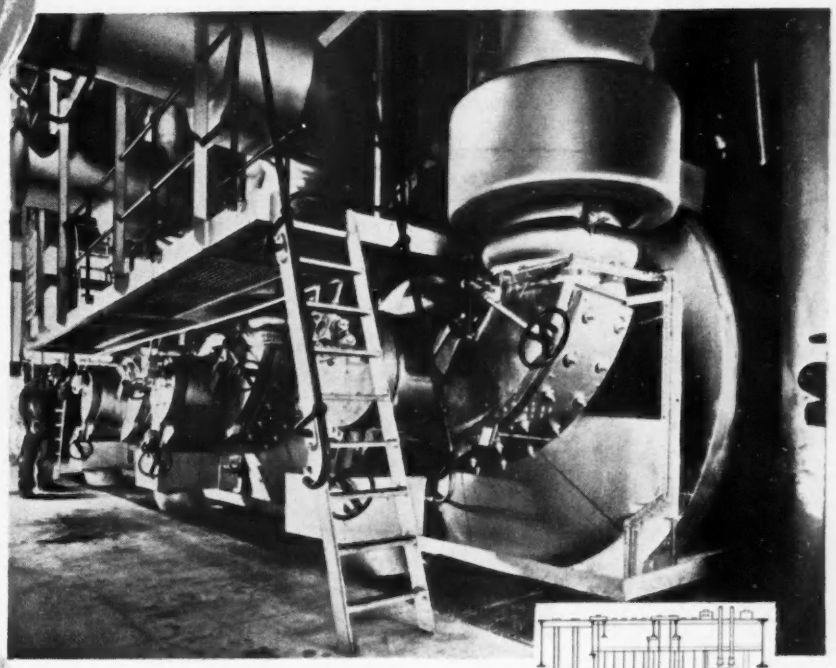

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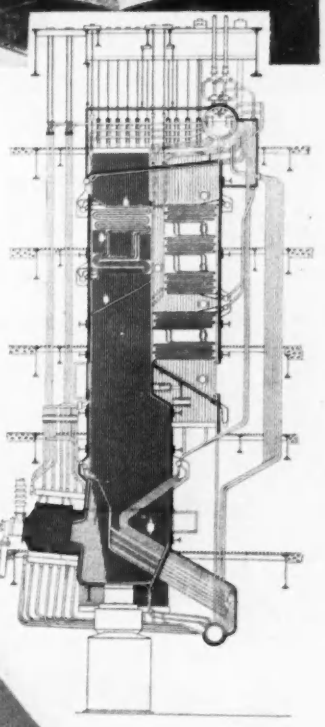

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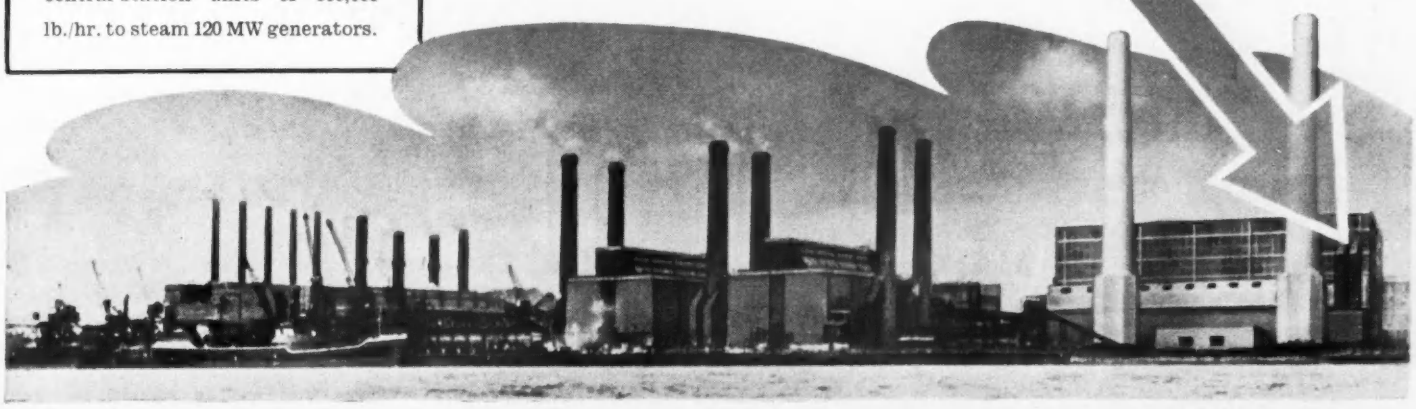

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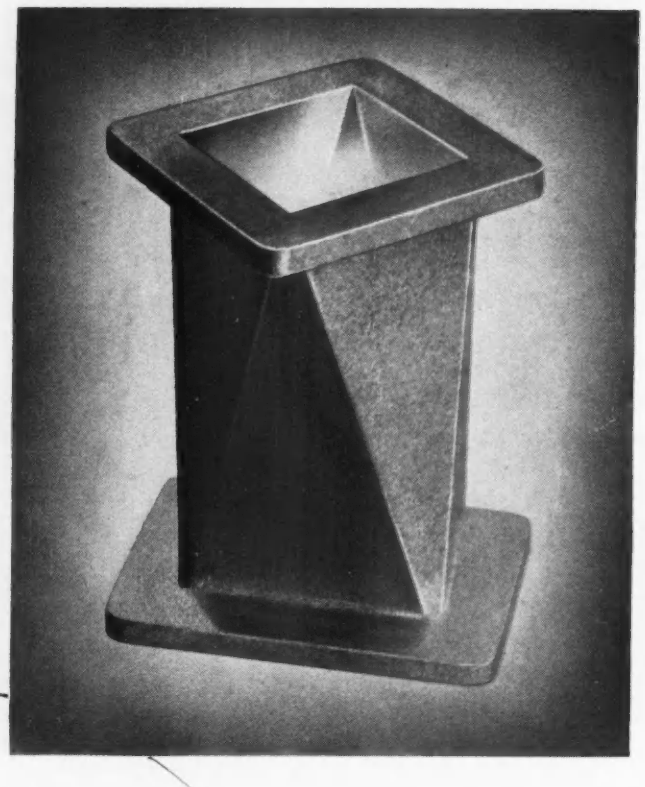

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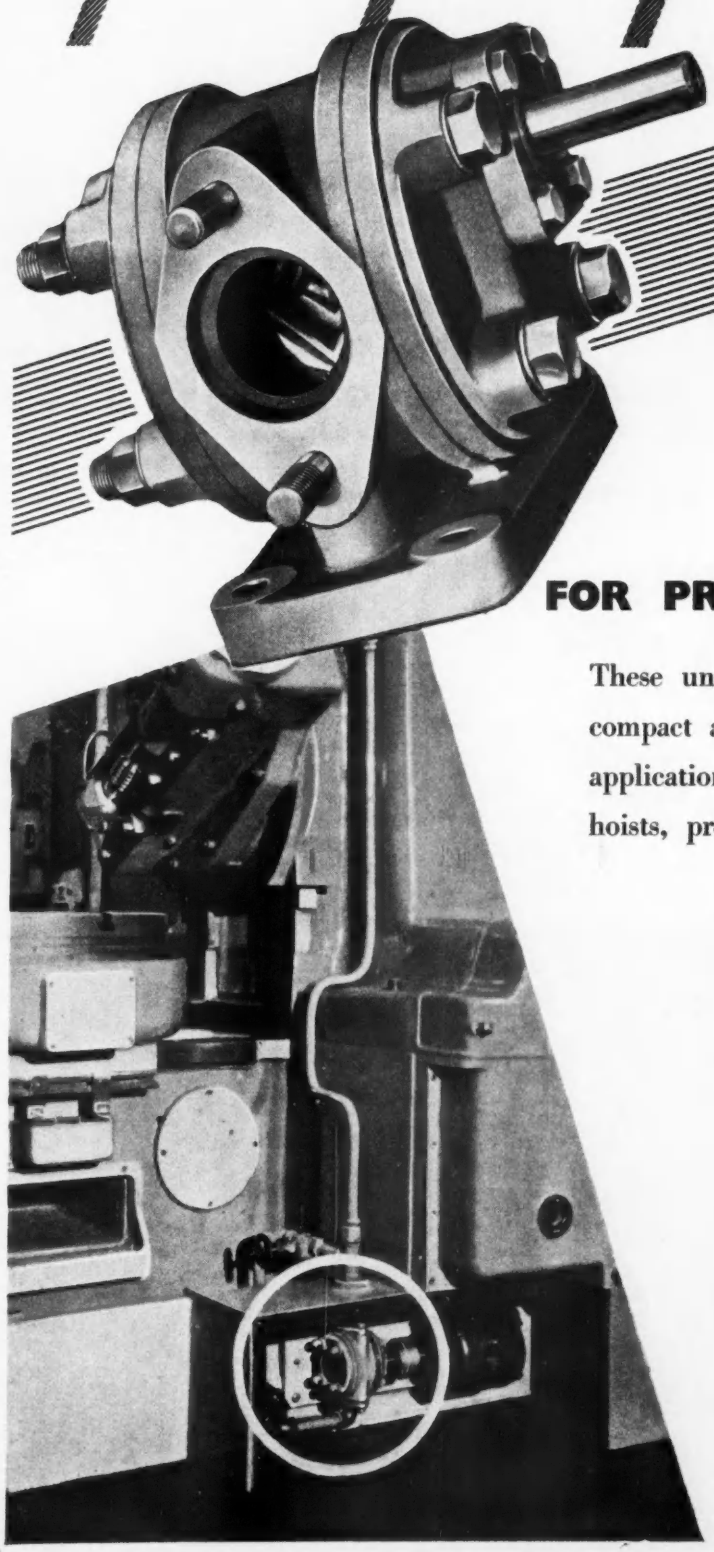

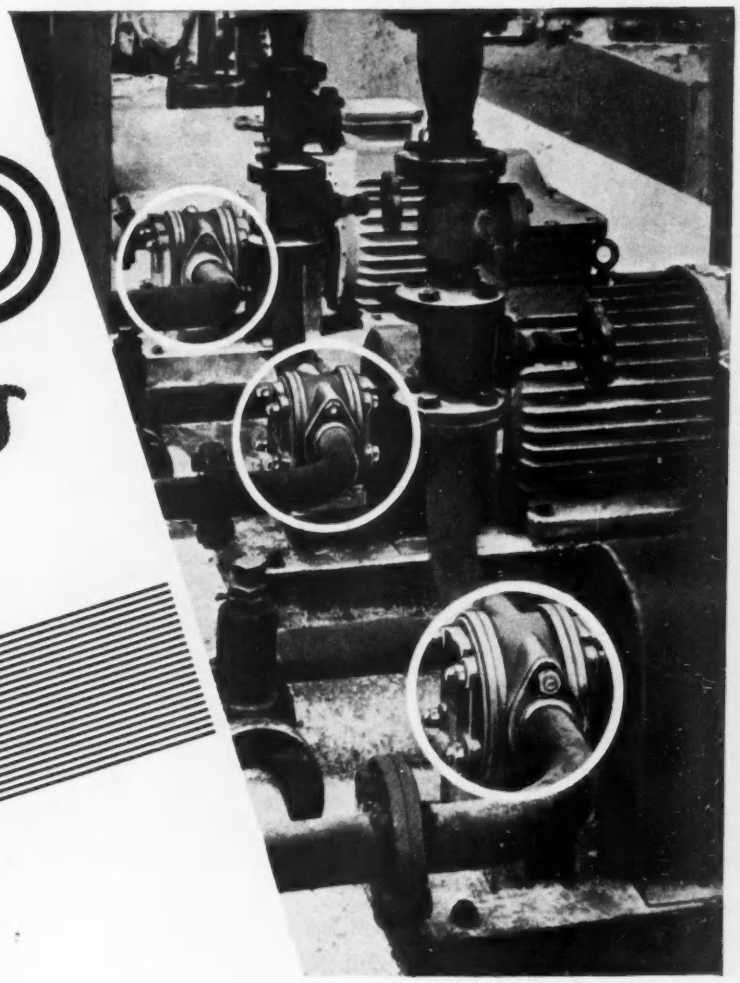

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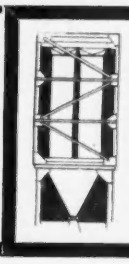

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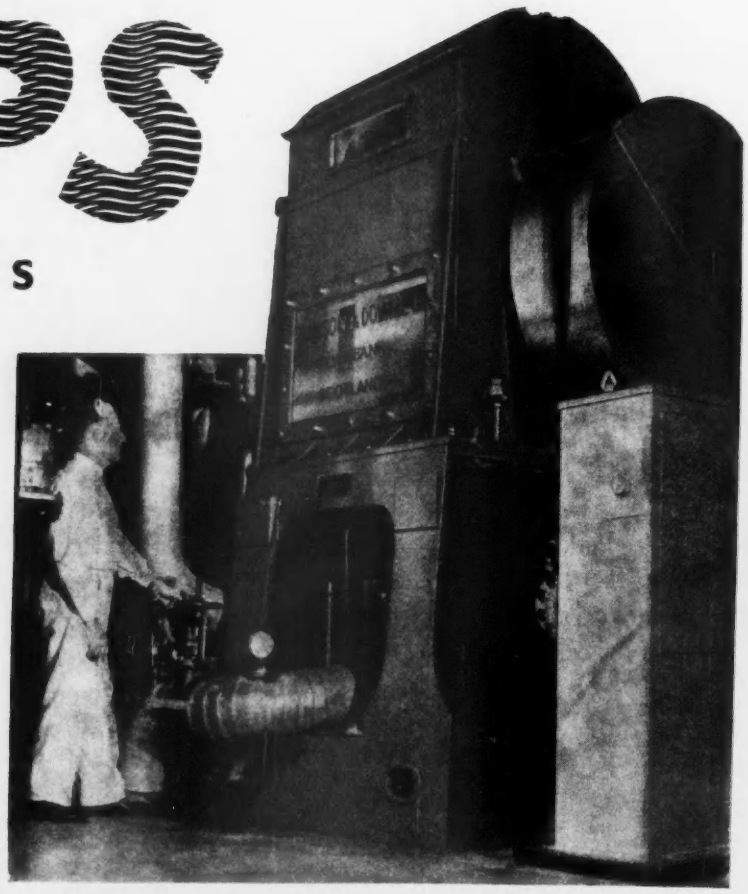

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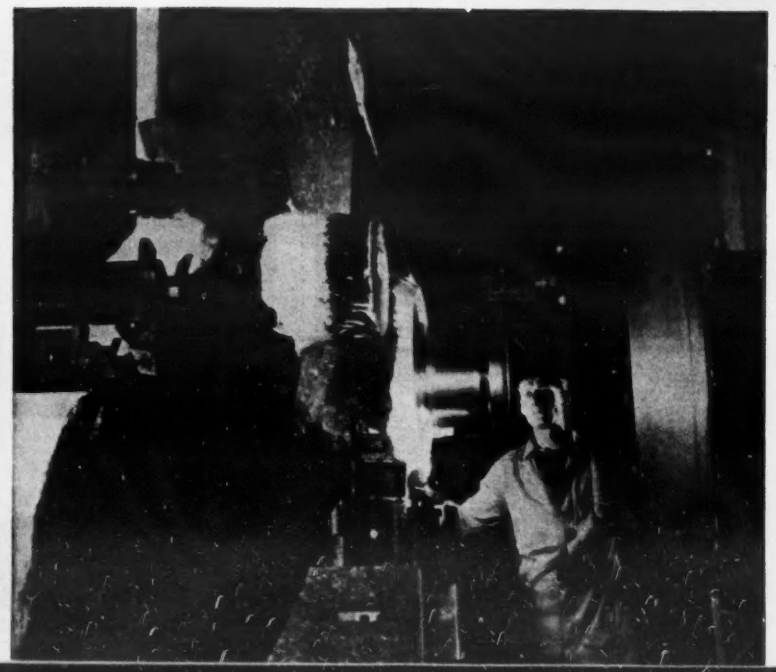

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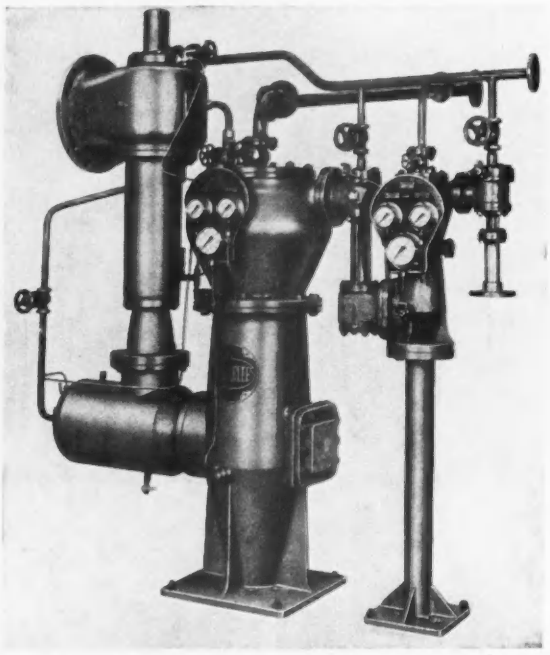

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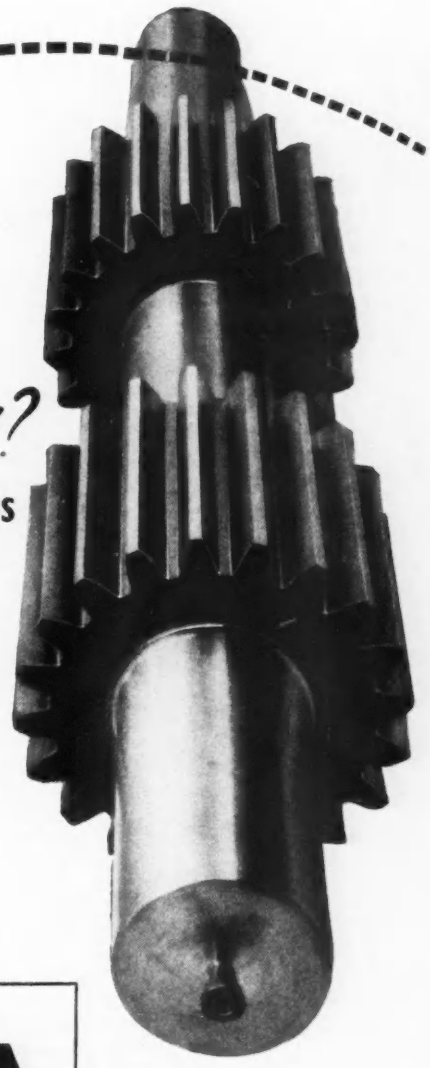

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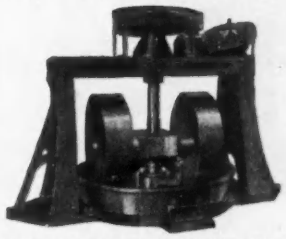

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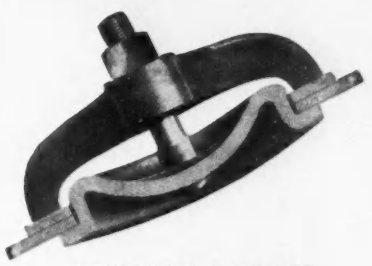

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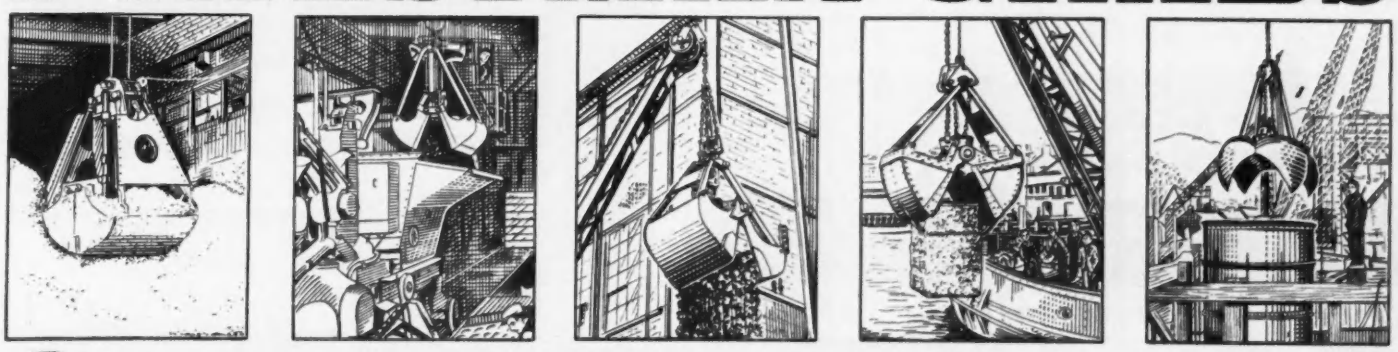

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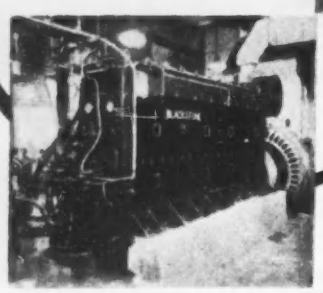

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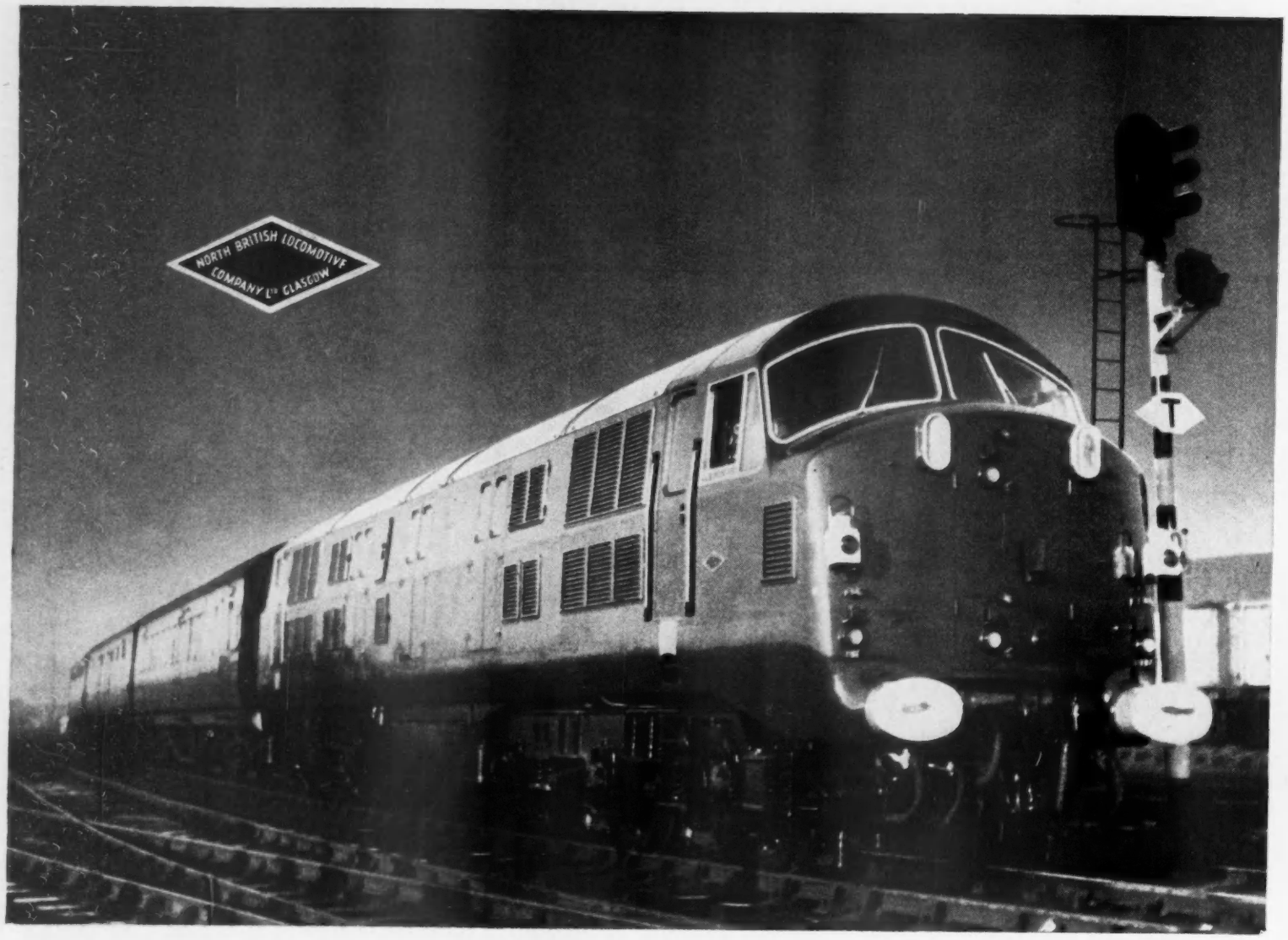

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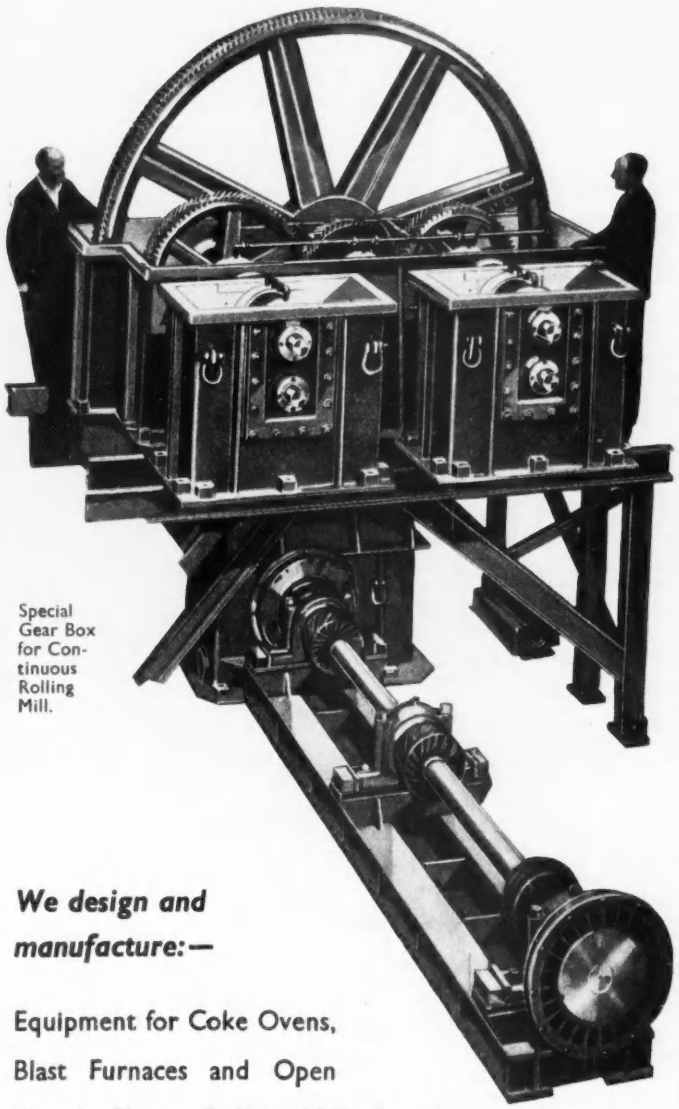

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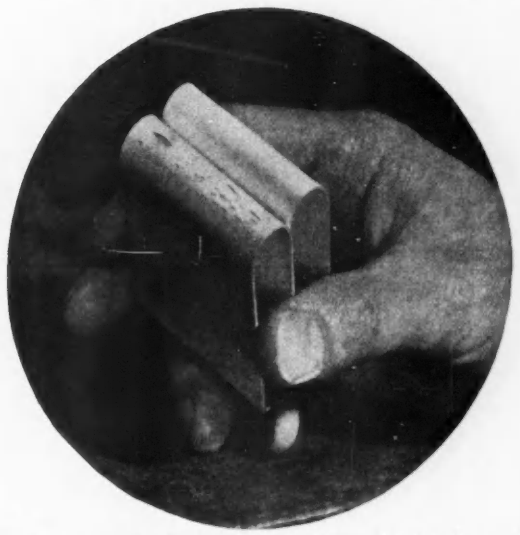

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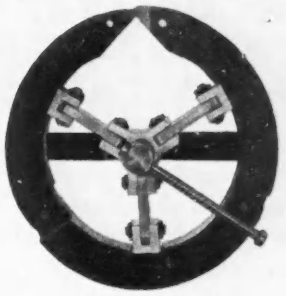

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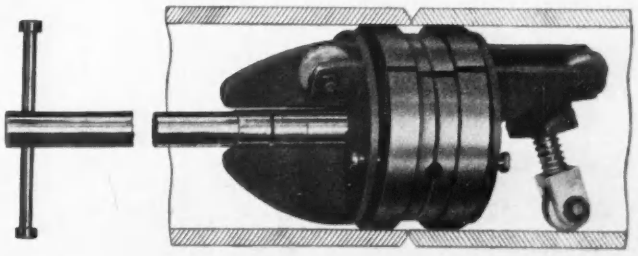

The aligner, in the contracted position, is propelled along the pipe internally in a position between the pipes to be butt welded. By operating a tommy bar on the end of extension tubes the aligner is expanded and presses out the pipe walls to their truly round form. Pressure holds the two pipes together in perfect alignment whilst the weld is laid—the aligner is then contracted and rolled along the pipe for the next weld.

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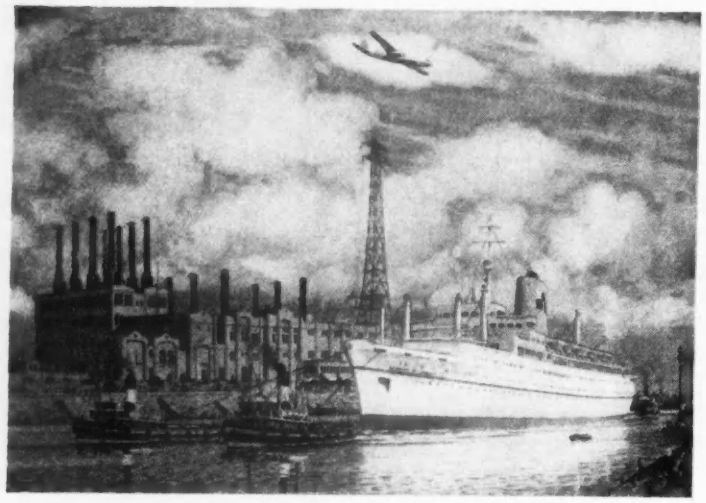

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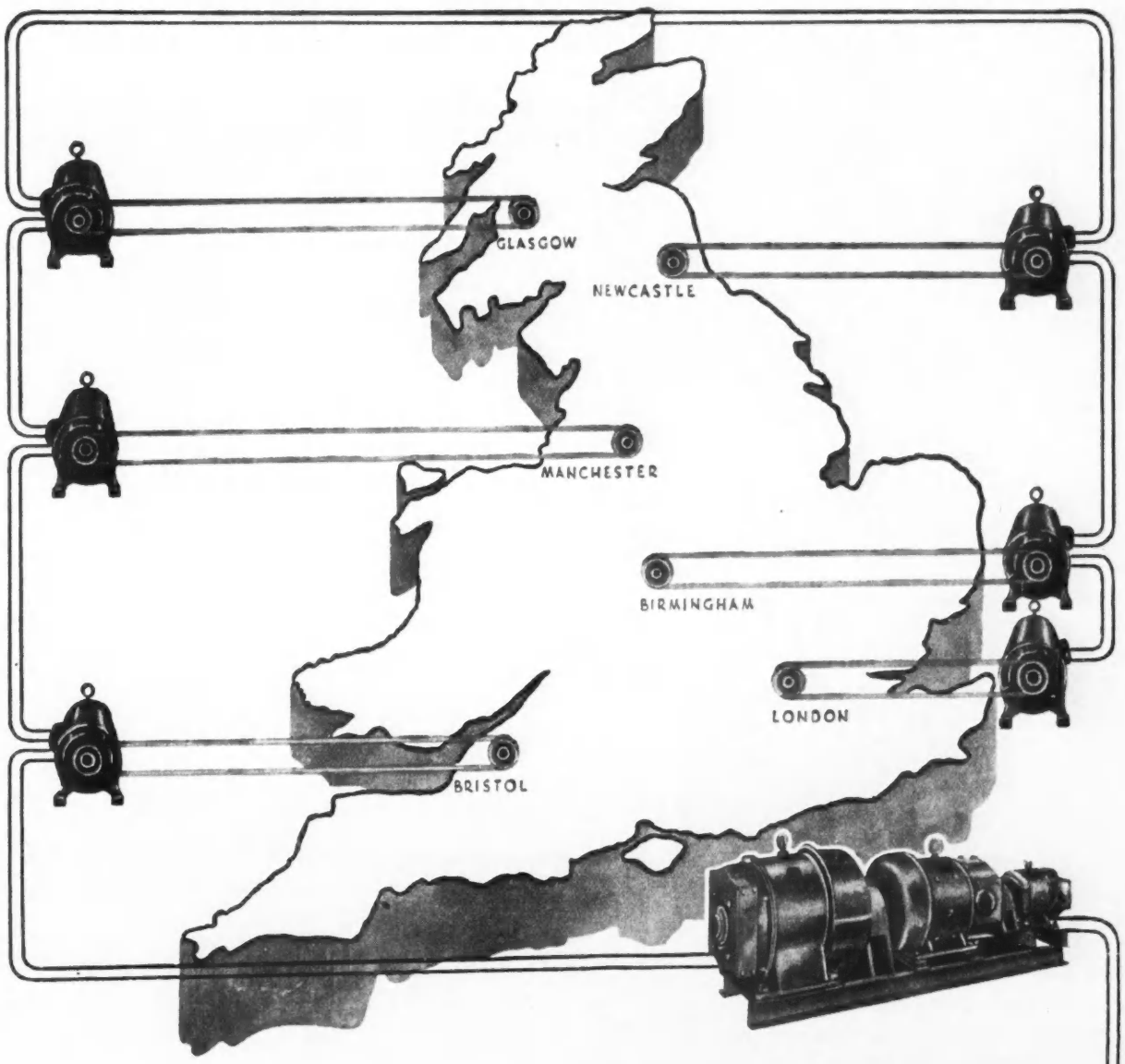

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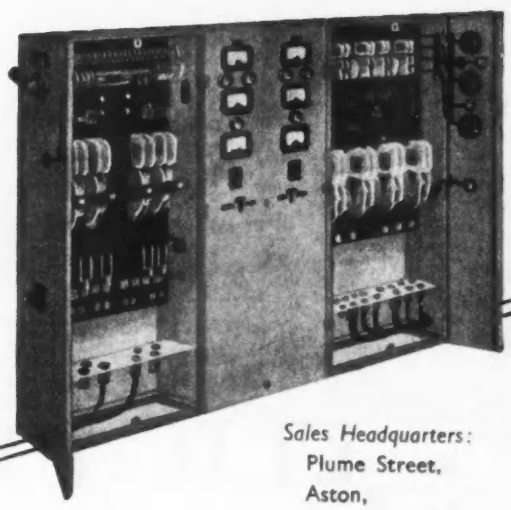

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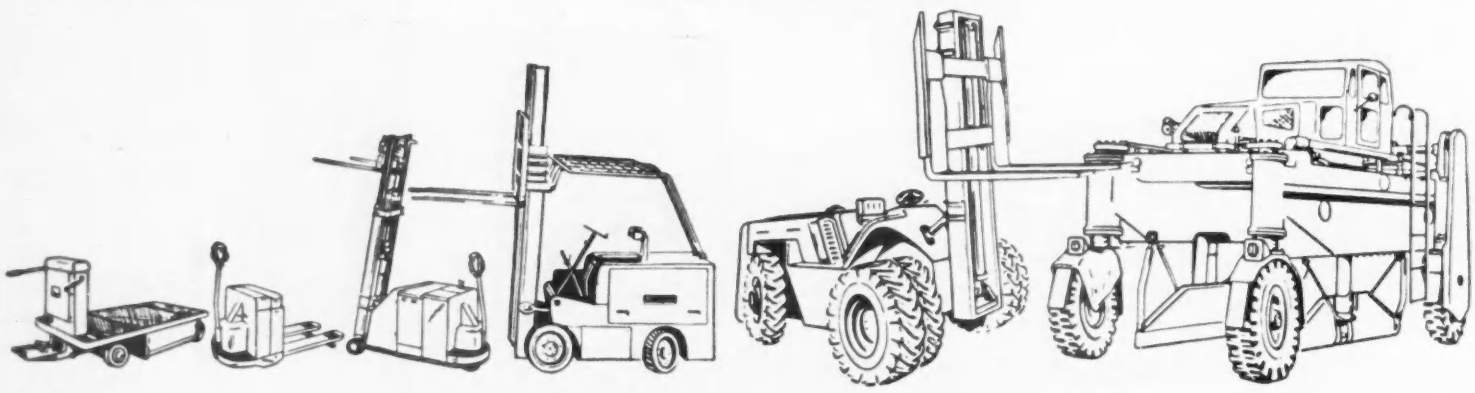

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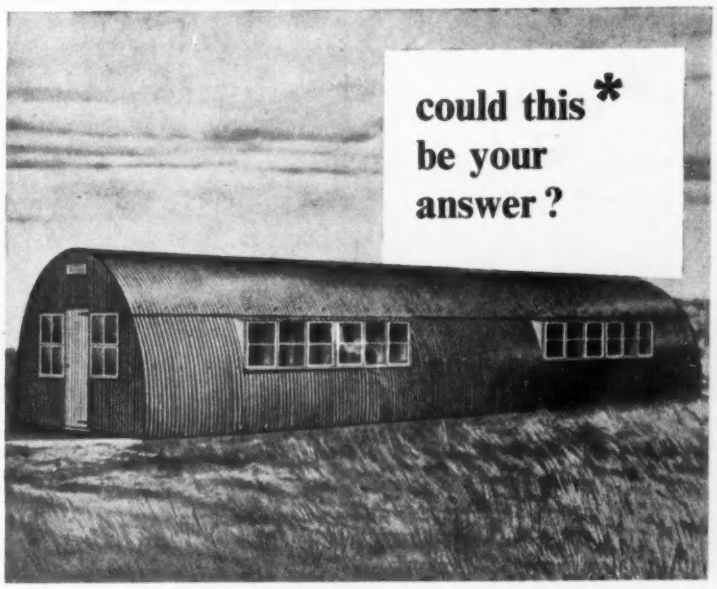

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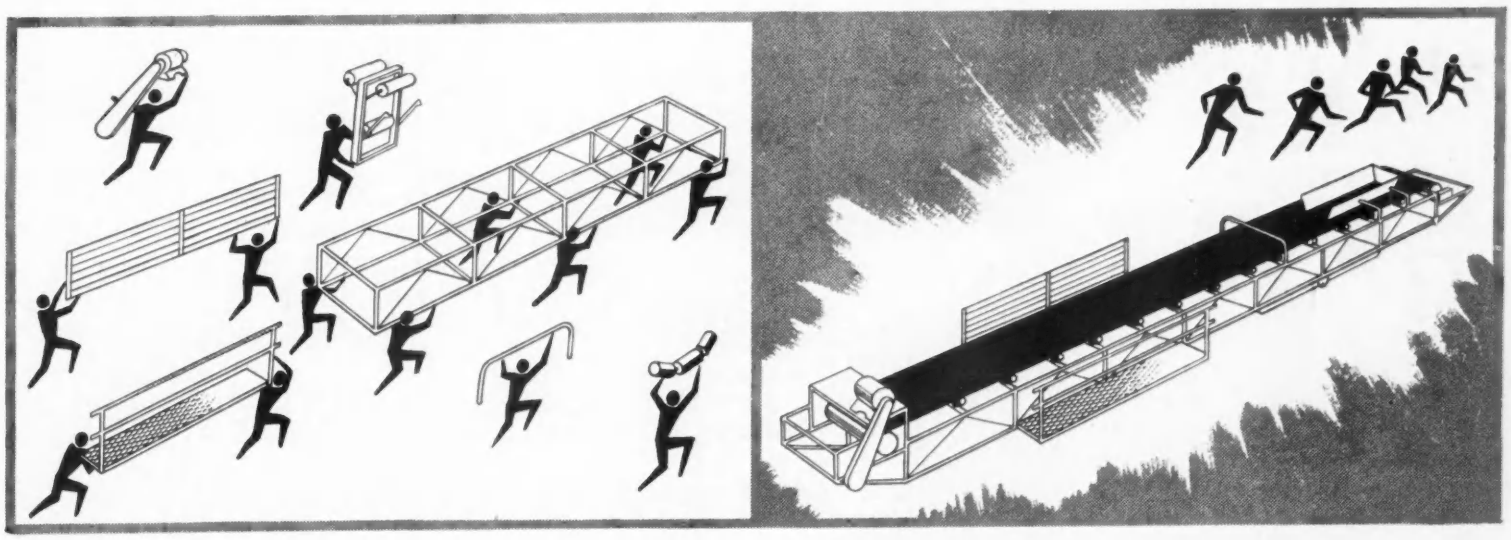

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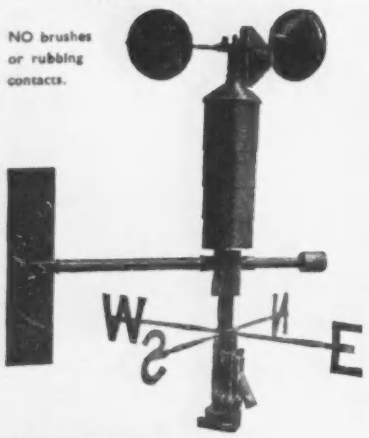

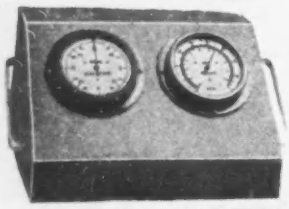

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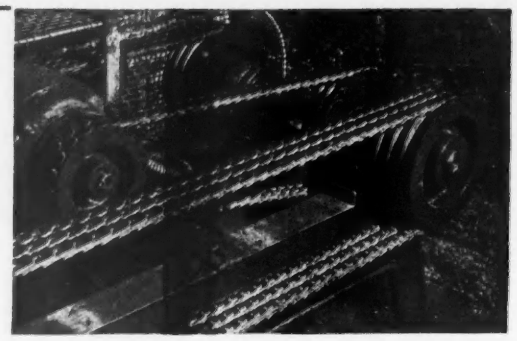

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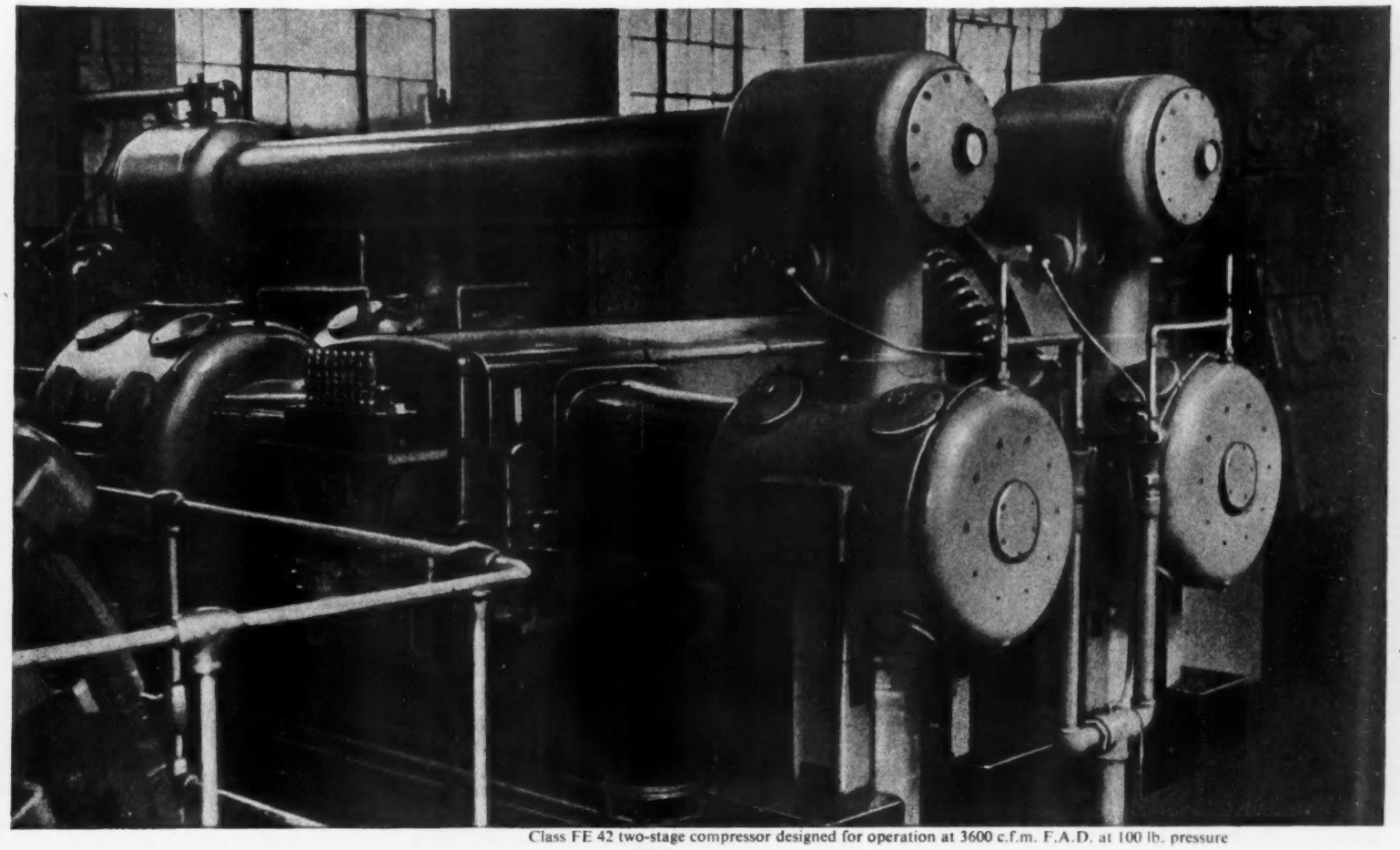

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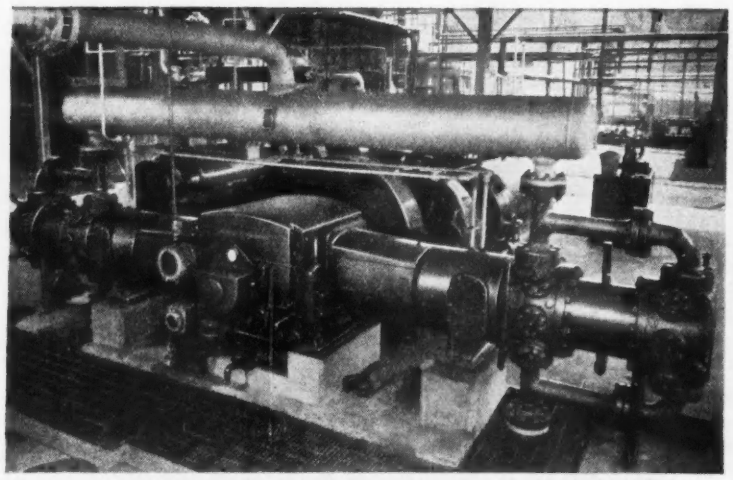

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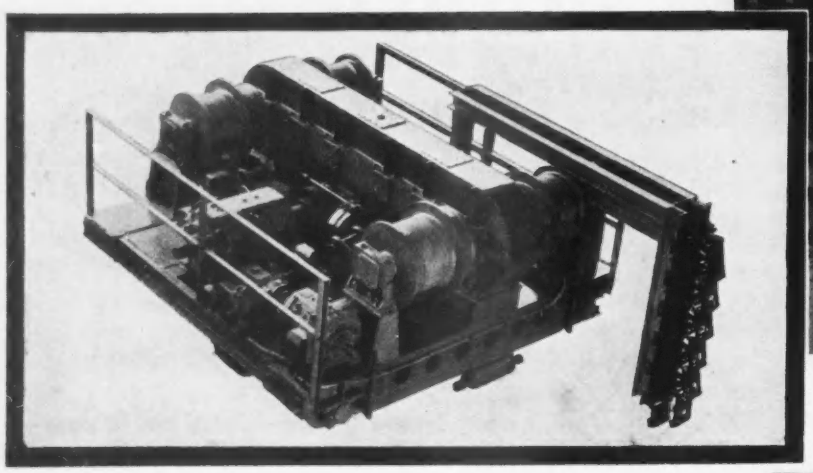
(ABOVE) Clyde-Booth four point suspension electric overhead travelling magnet crane at Messrs. Colvilles Ltd., Ravenscraig Works.
(RIGHT) The hook with slip-ring gear for the magnet, showing attachment of the four ropes.
(BELOW) The special four barrel crab.



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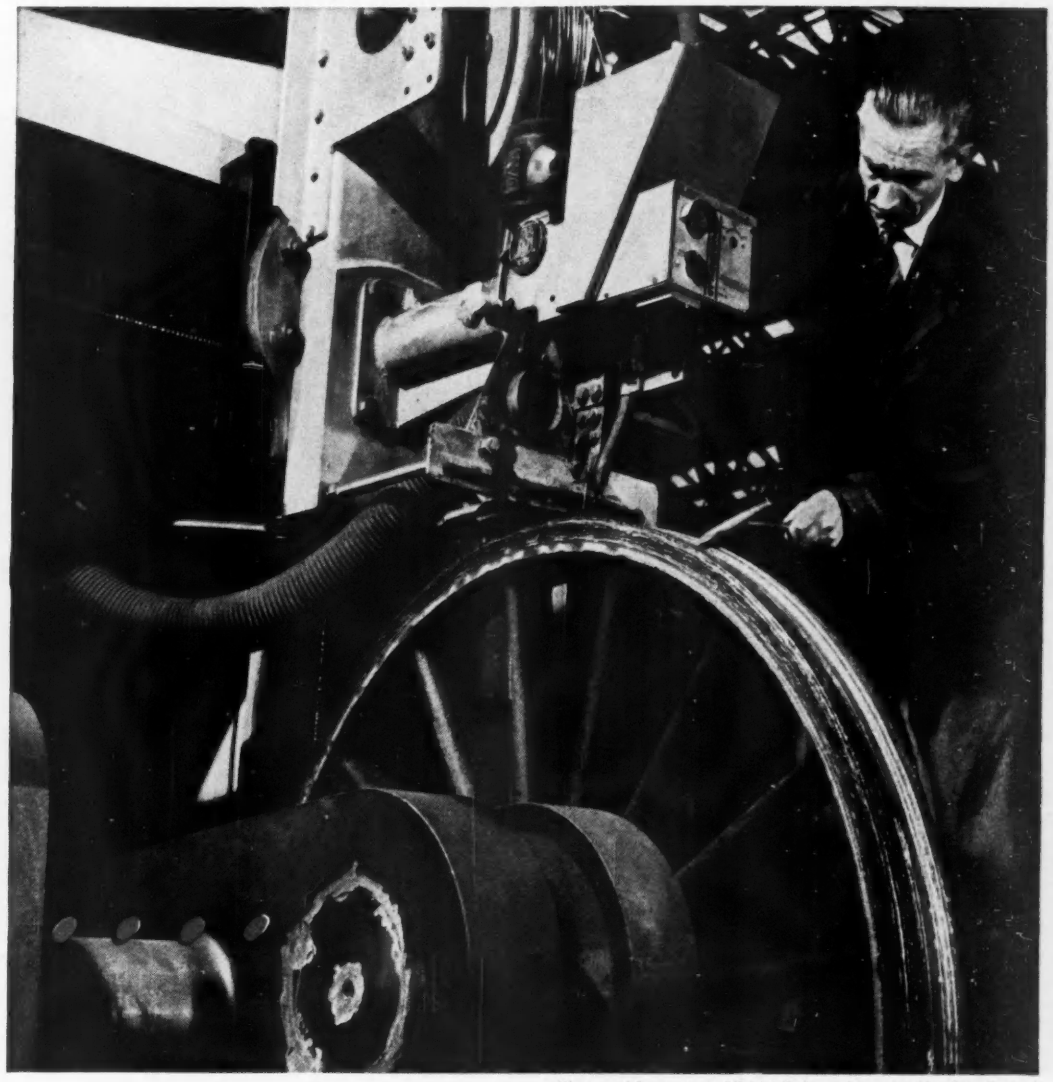
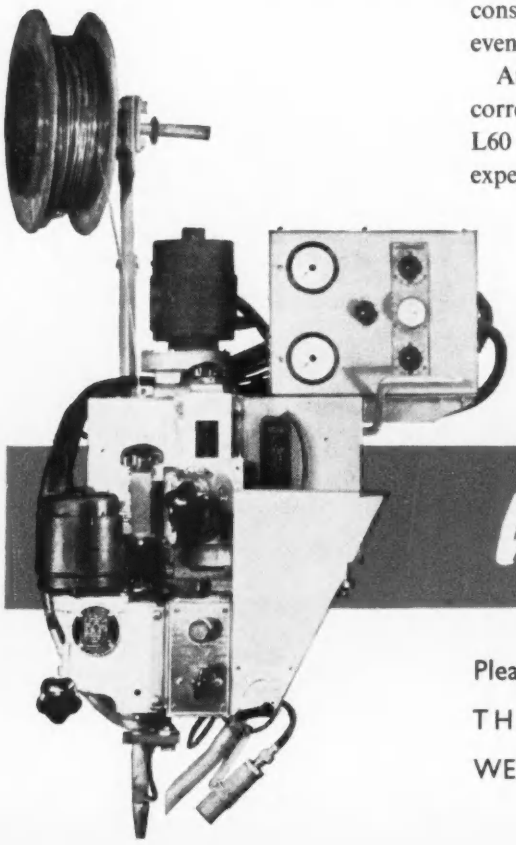


Photograph by courtesy of British Railways Magazine (Southern Region)



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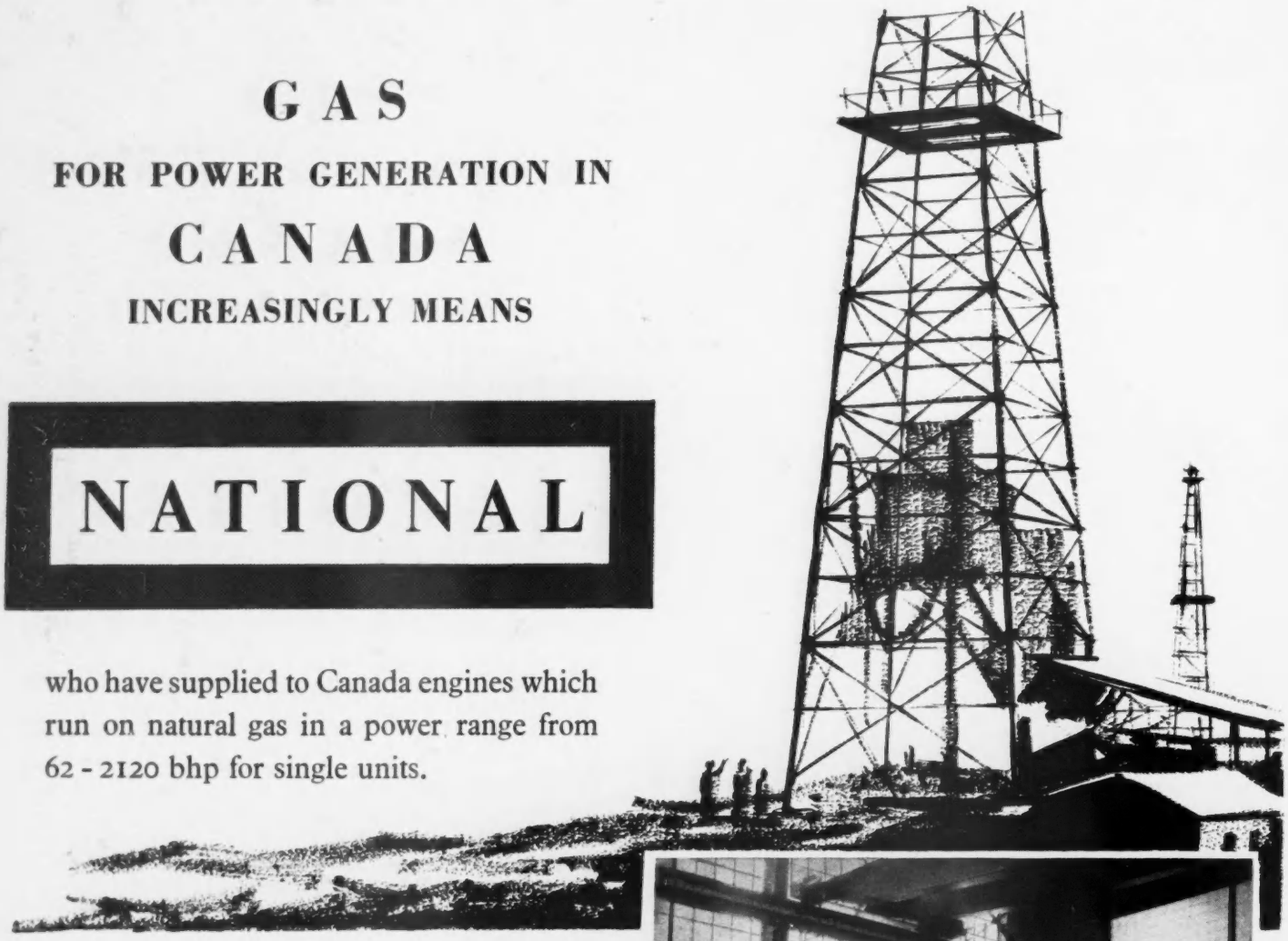

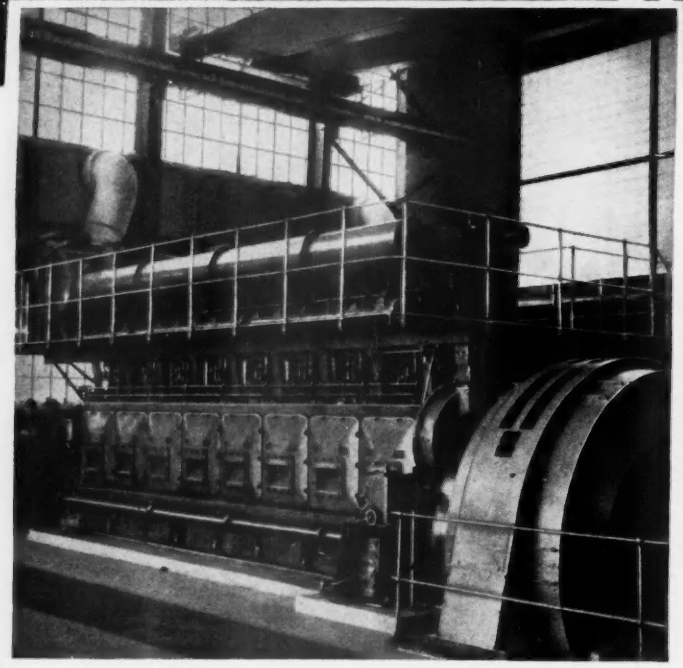

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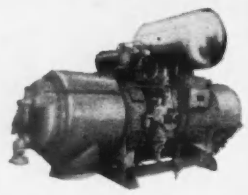

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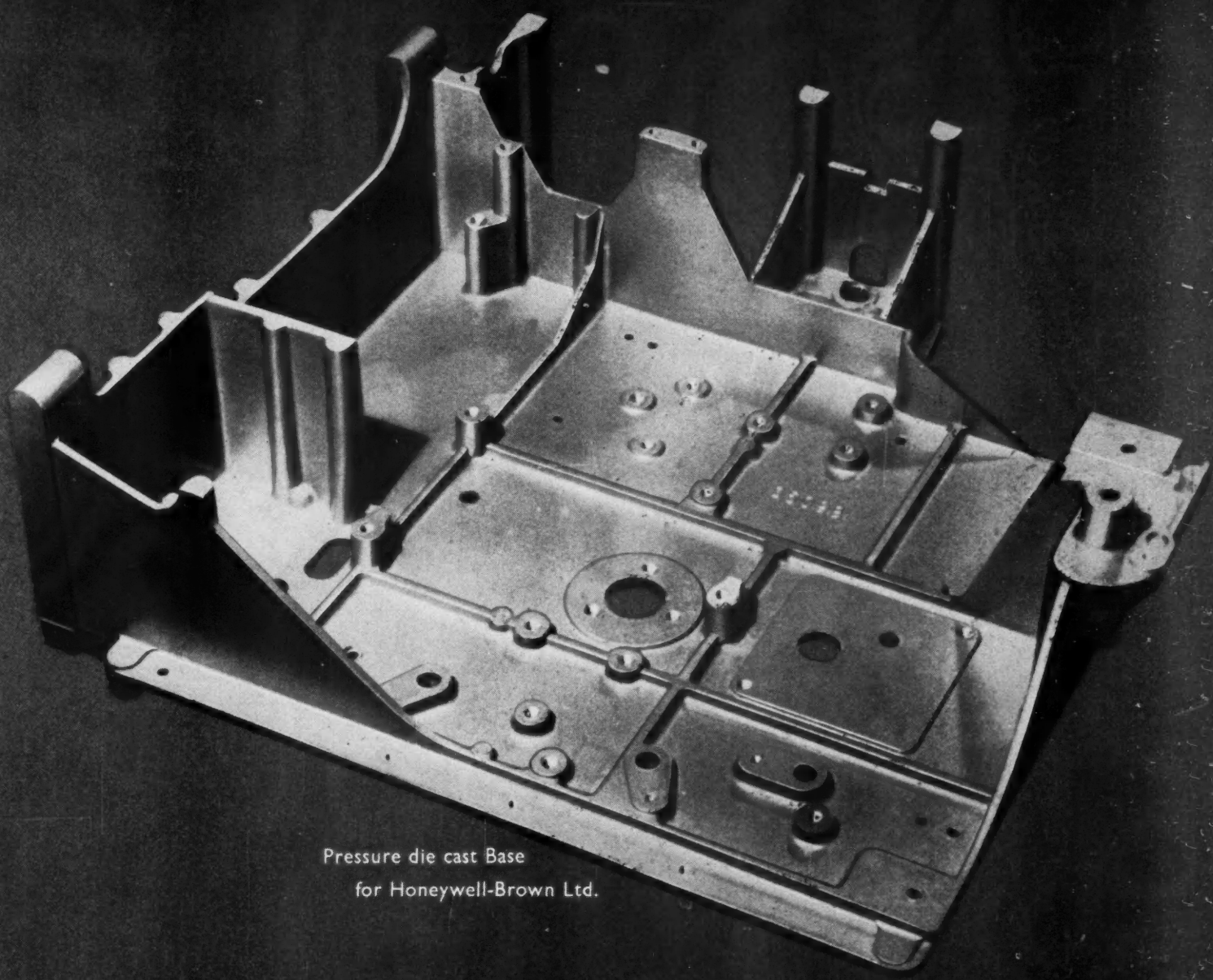

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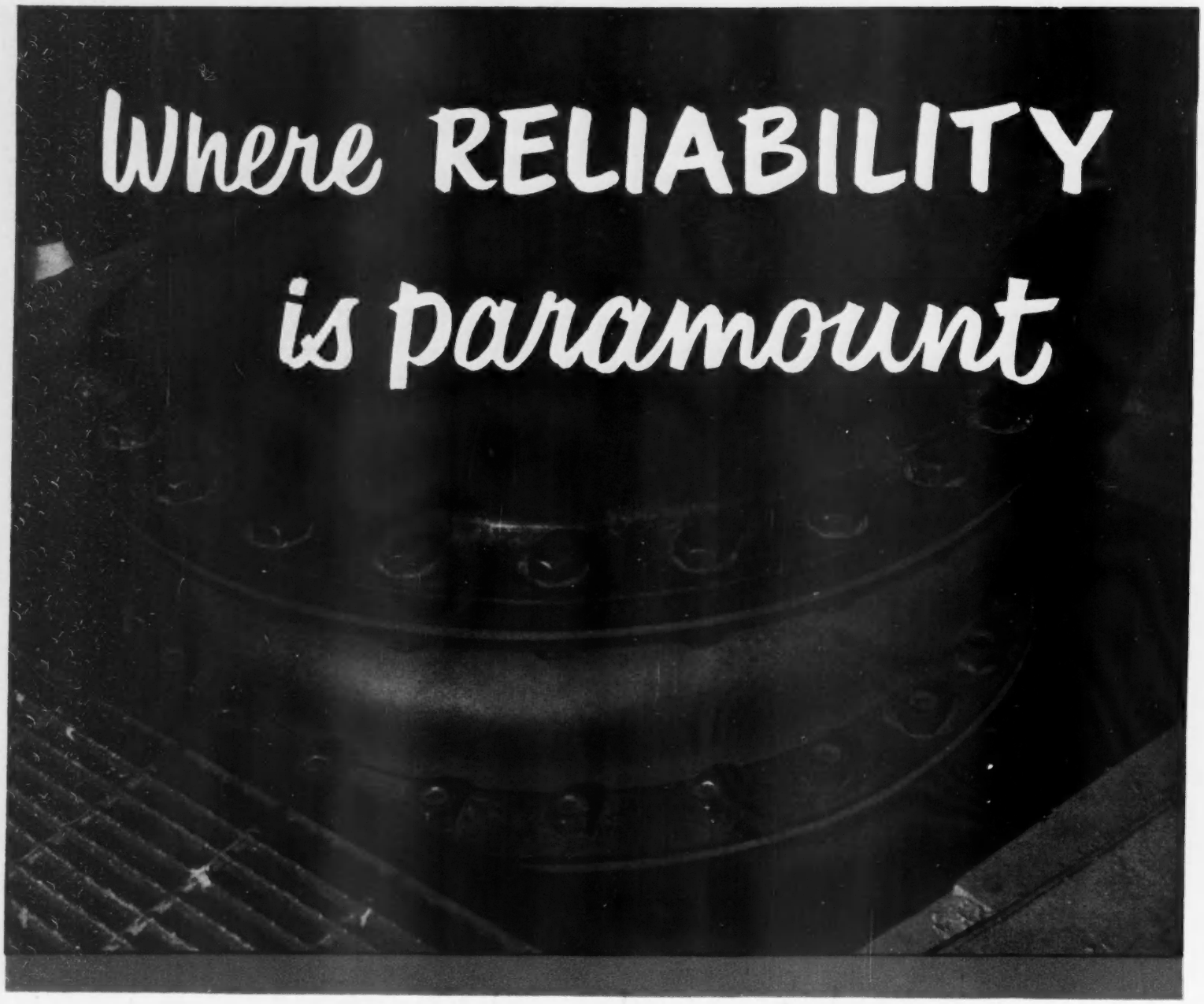

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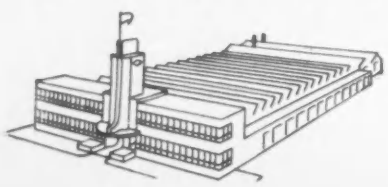

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Putting two and two together and making five ! At least, that's how it appears when you consider the saving in time and cost by changing over to tapping screws.
Without doubt, the tapping screw does display a number of very definite advantages over the conventional machine screw. It obviates the use of nuts. With its self-locating point, it forms its own thread and eliminates a separate and expensive tapping operation.
It makes for easier assembly, is stronger, cheaper and faster. And when used in conjunction with the Phillips recessed head, designed for power driving without damage to either work or worker, it is obviously safer. Putting two and two together, the tapping screw simply ensures a better job.
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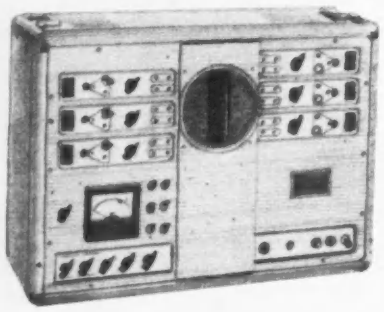
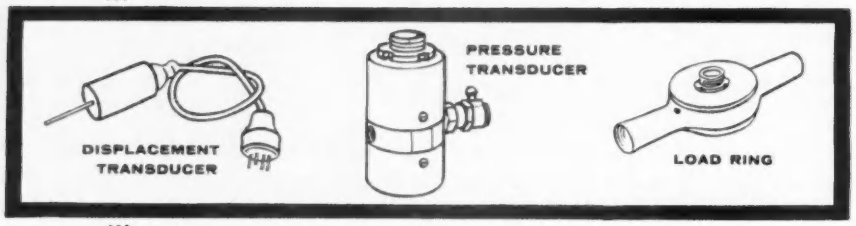
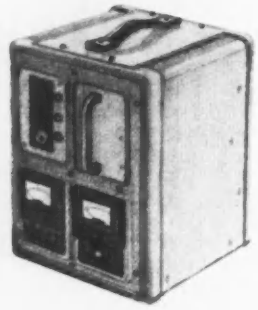


6 CHANNEL C.R.T. FILM RECORDER





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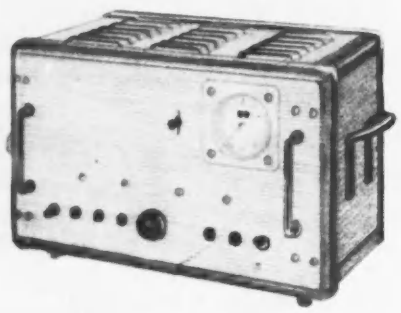

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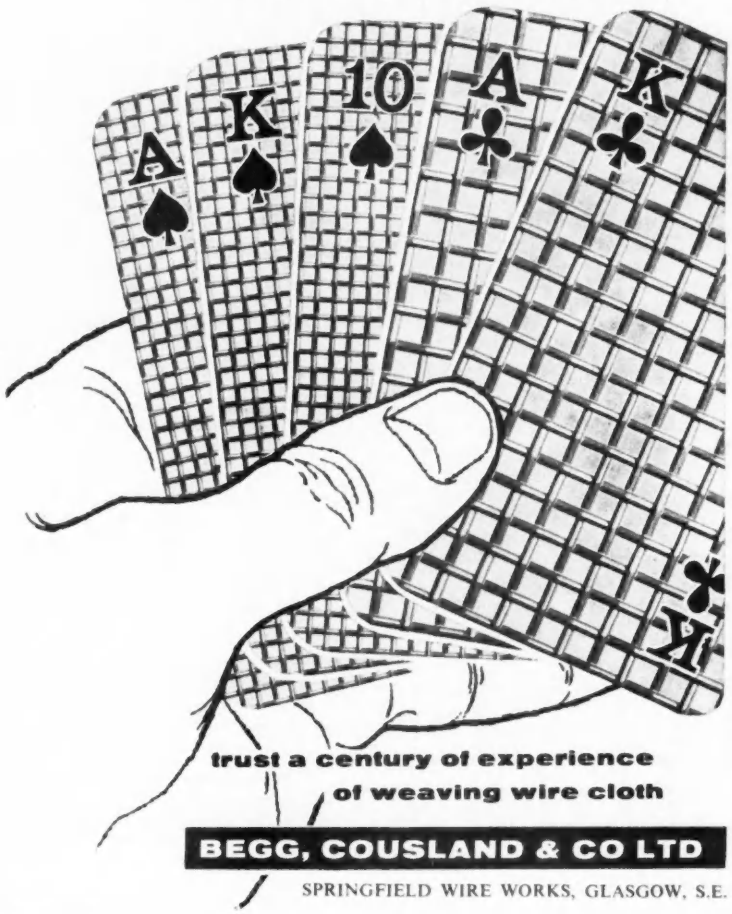

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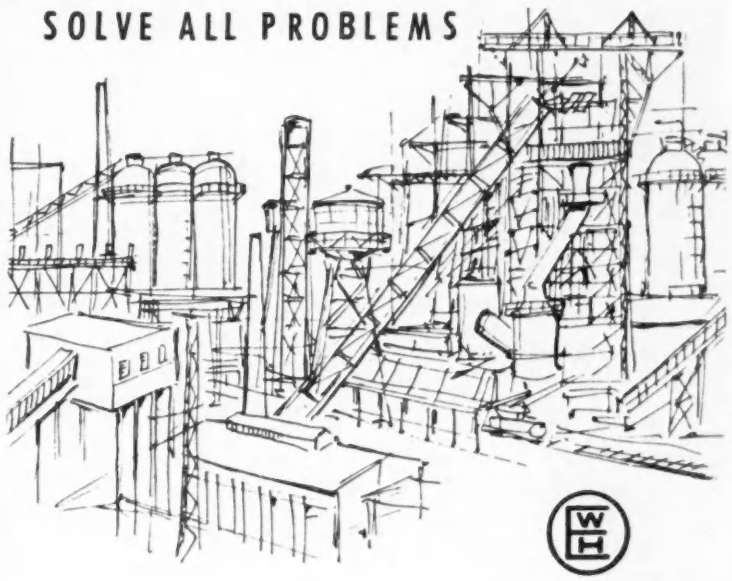

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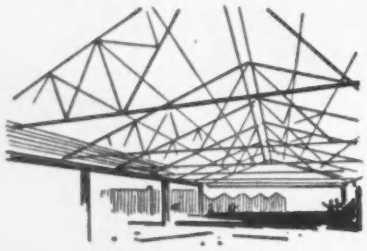

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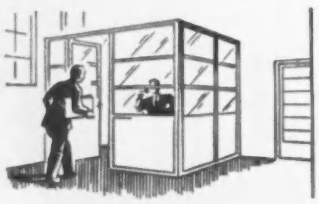

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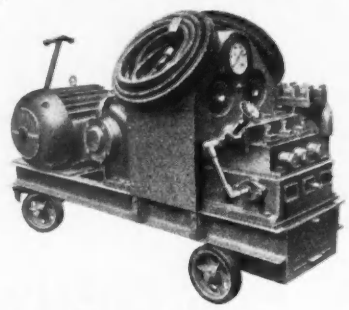

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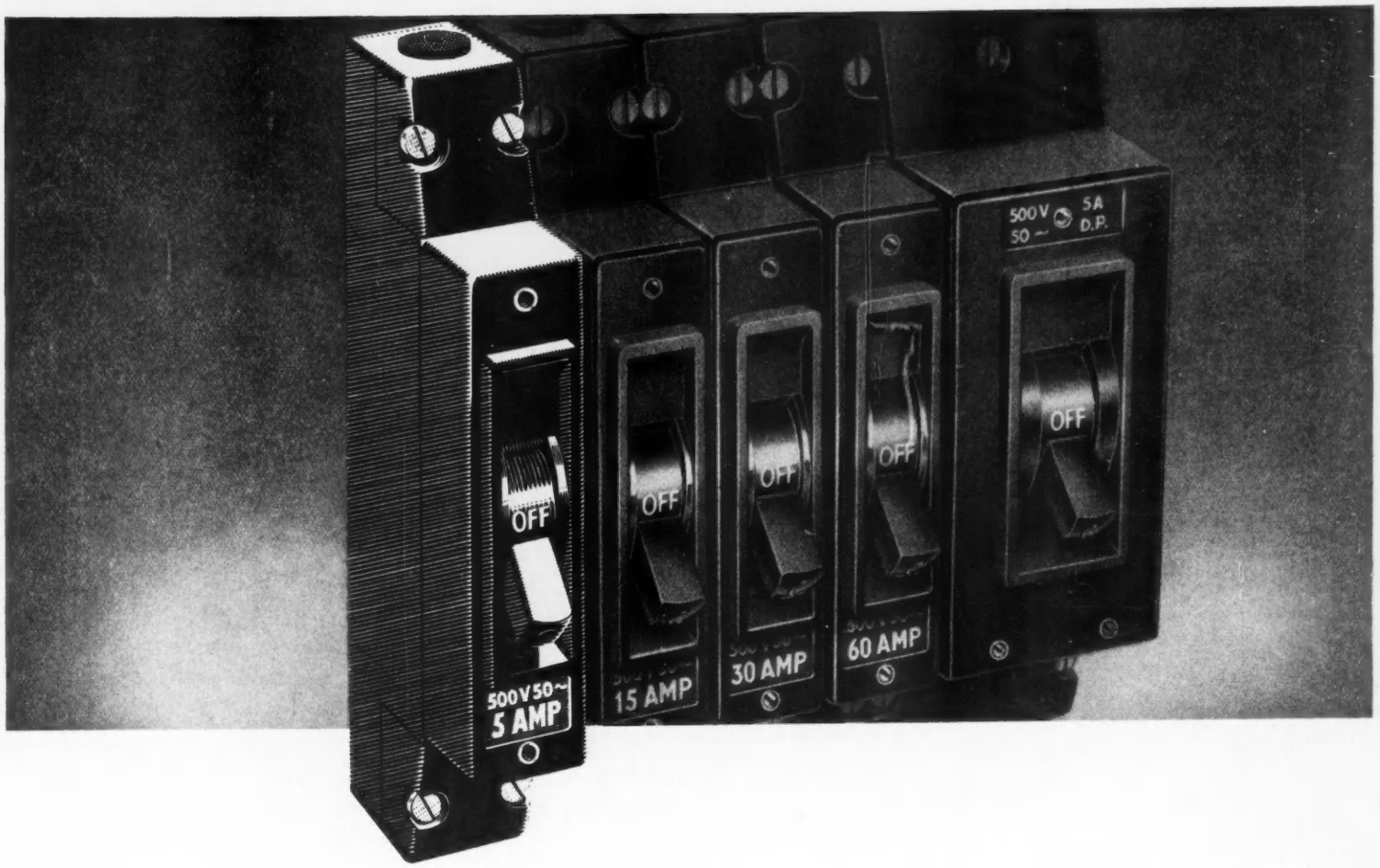
CRABTREE MINIATURE CIRCUIT BREAKERS



WHY THE USER PREFERS CIRCUIT BREAKER PROTECTION

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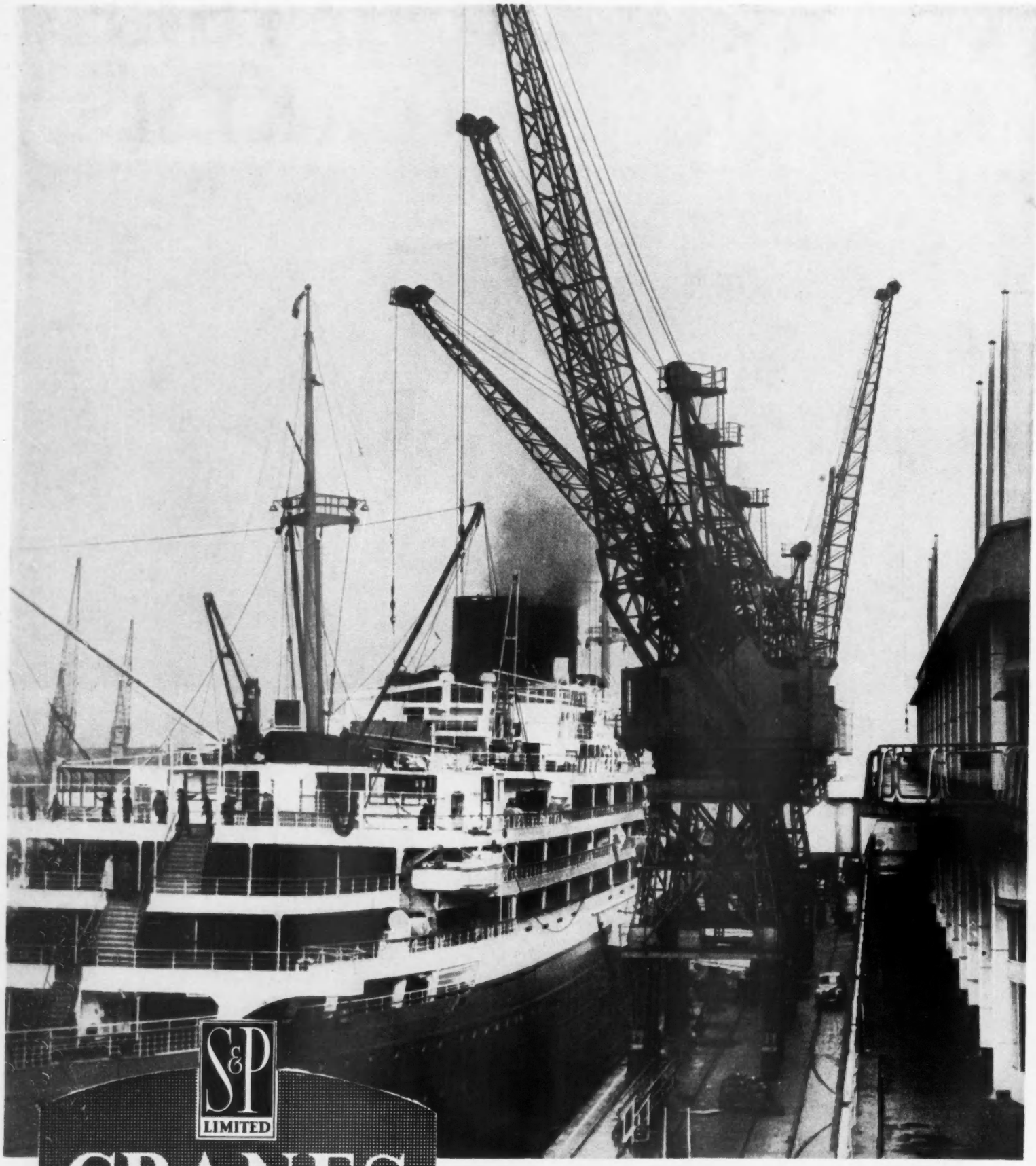

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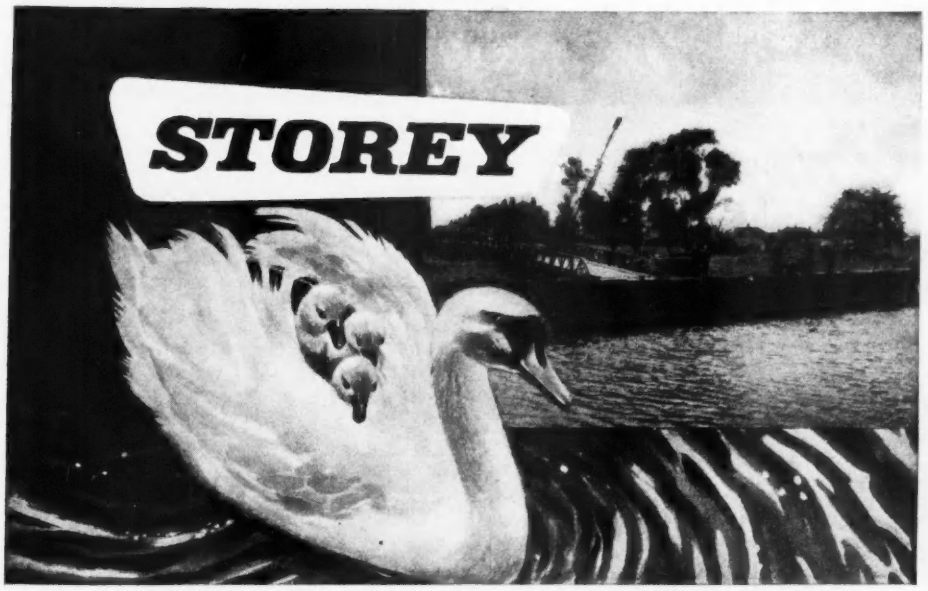

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The illustration shows the trial erection of the N'kata Bay Landing Stage, constructed from sixteen Uniflotes, decked with Storey Steel Decking and connected to land with Bailey Access Bridges.

Photo by courtesy of Sir William Halcrow & Partners.

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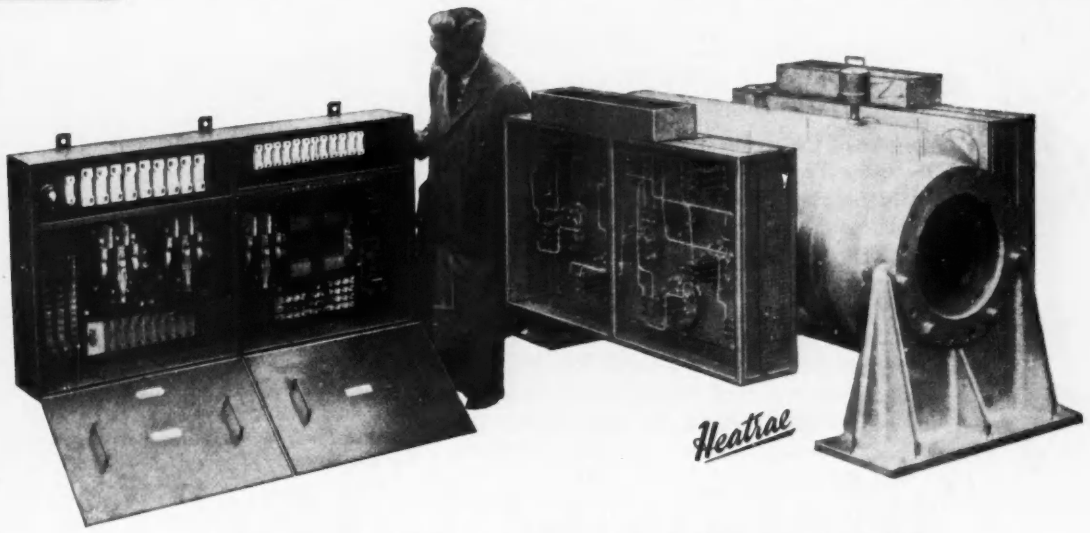

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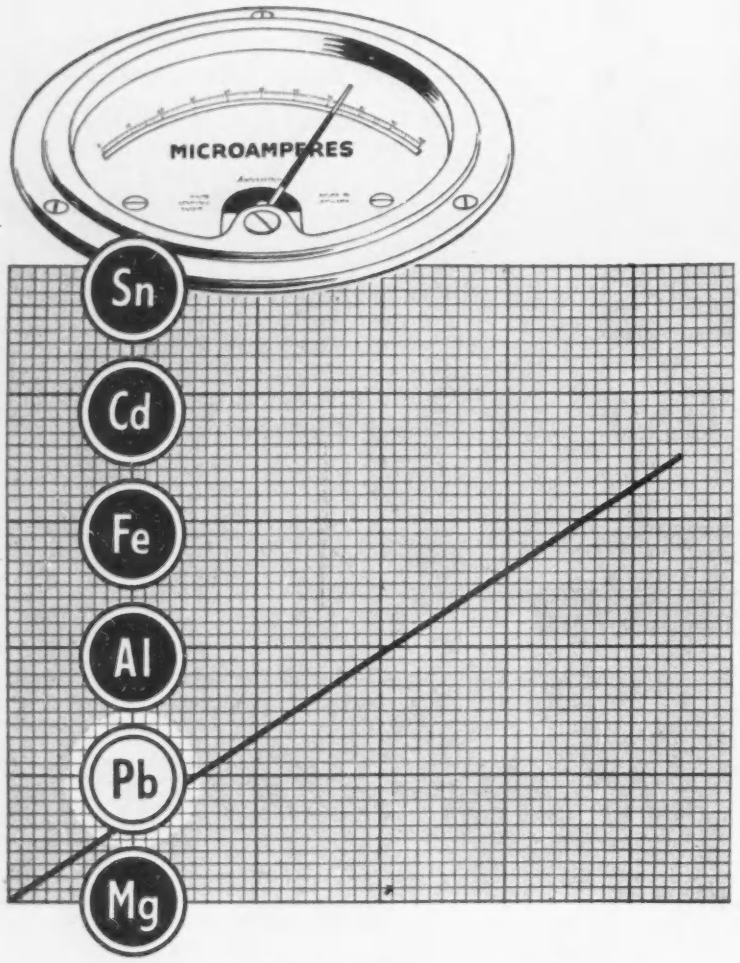

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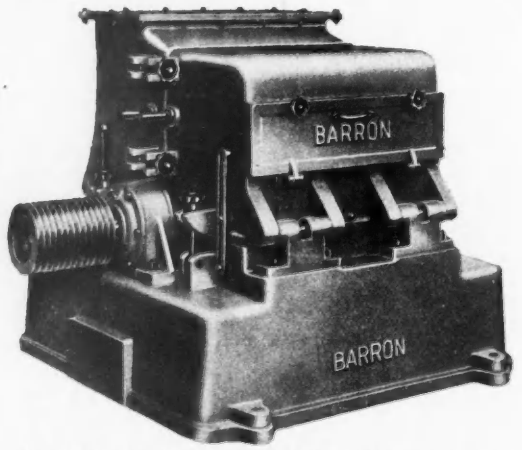

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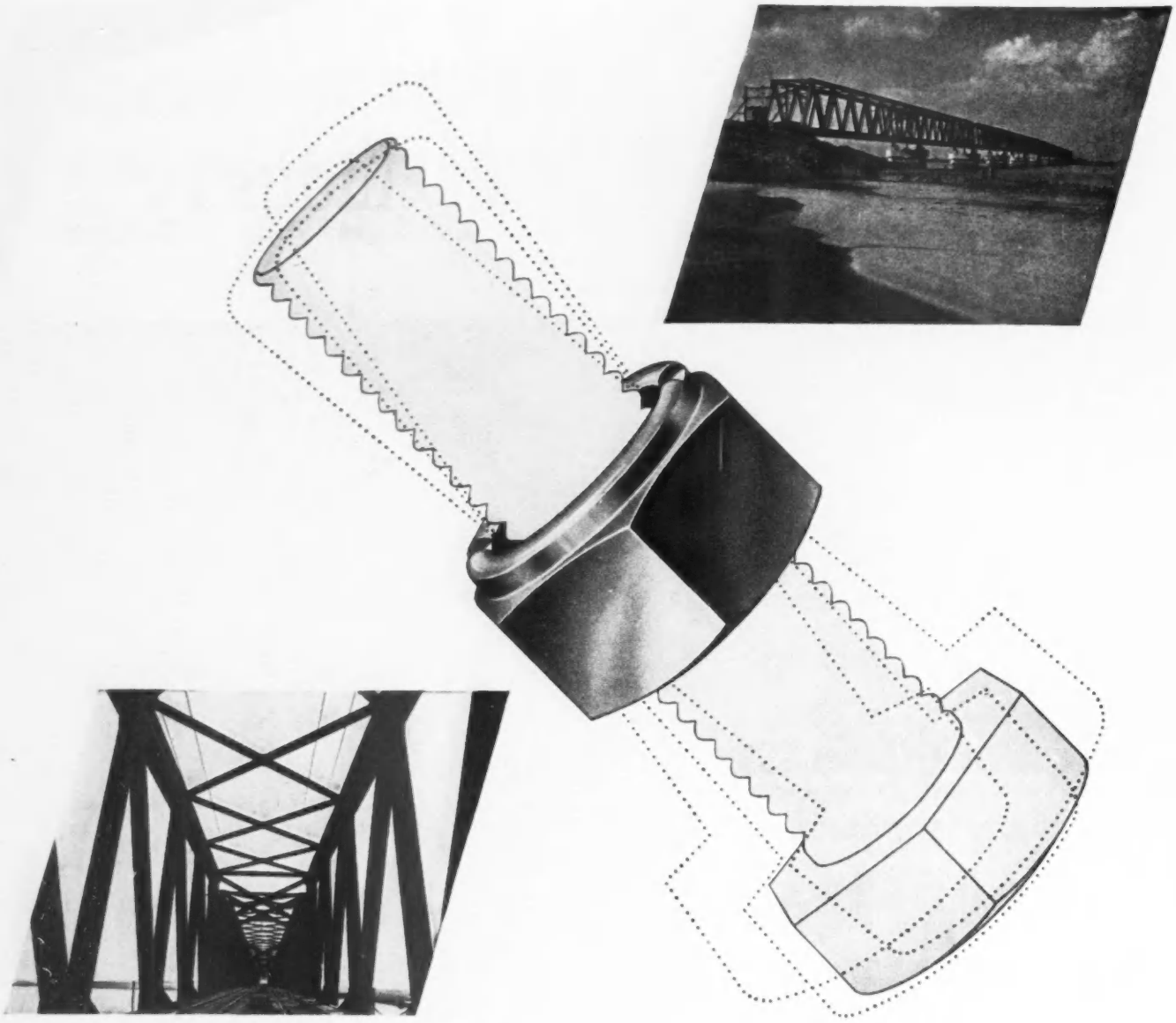

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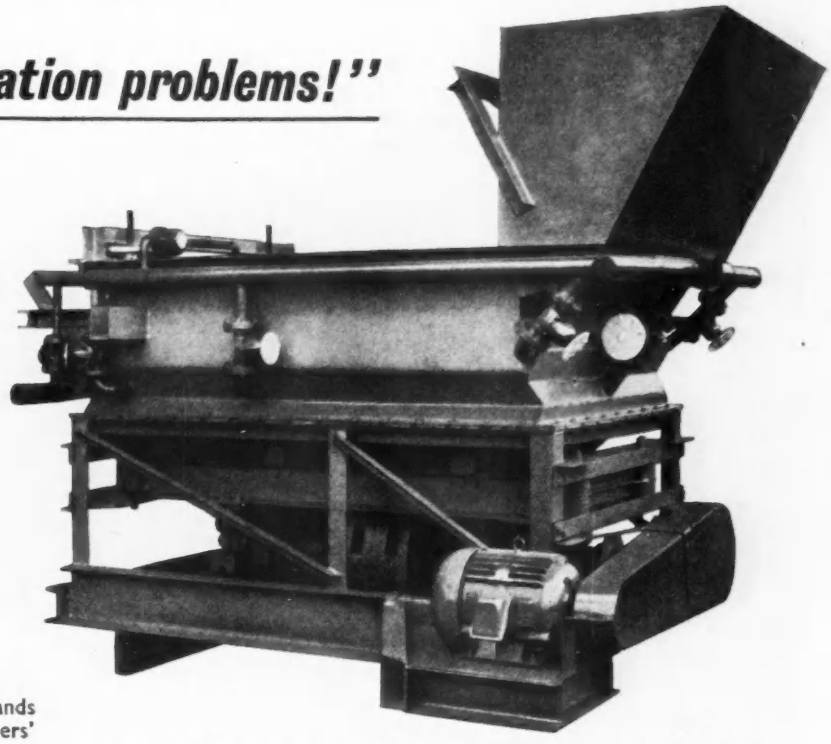

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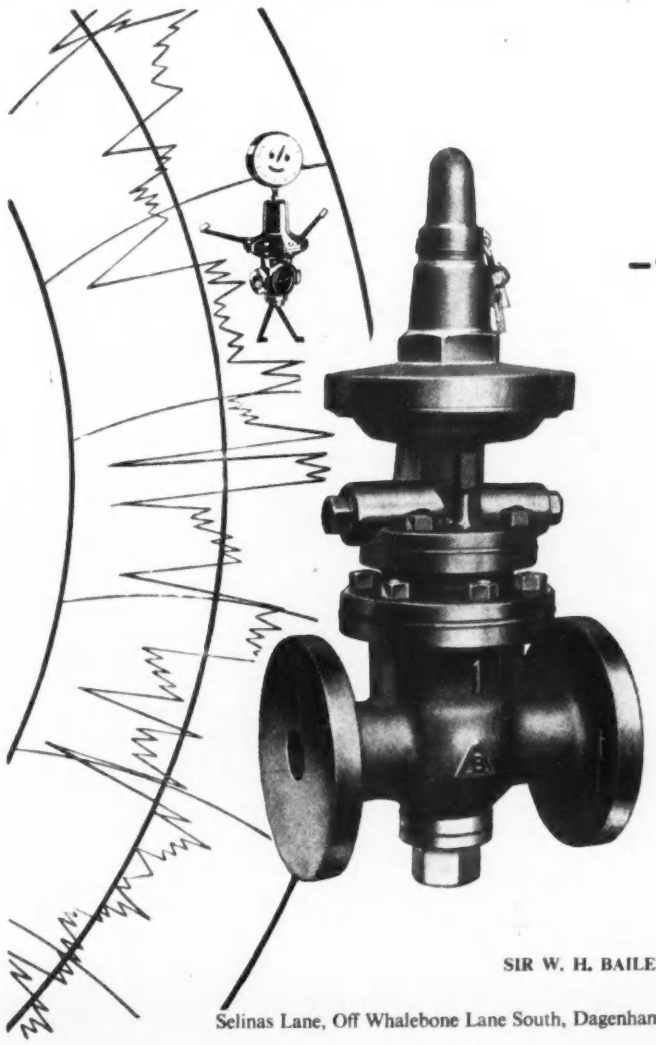

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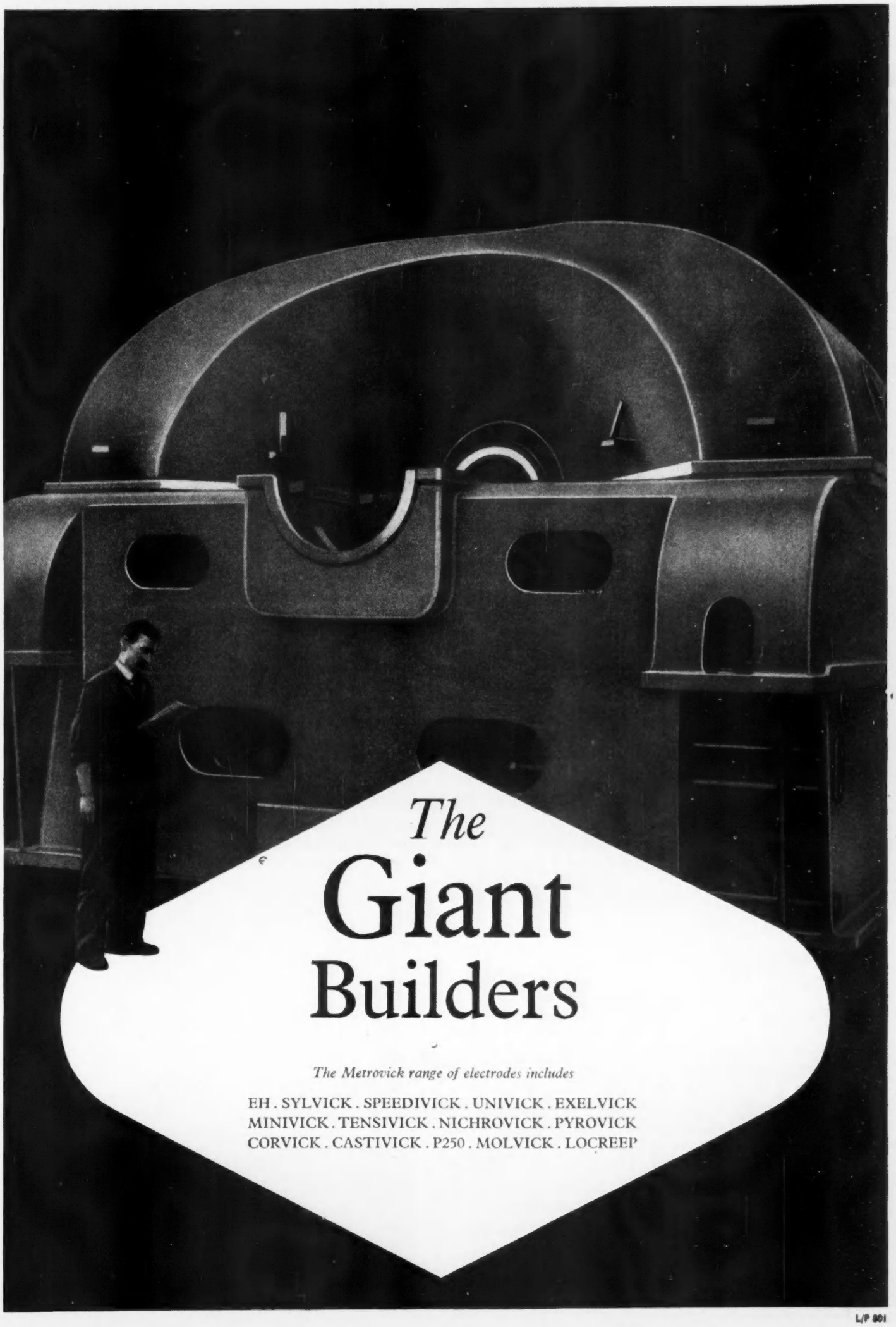

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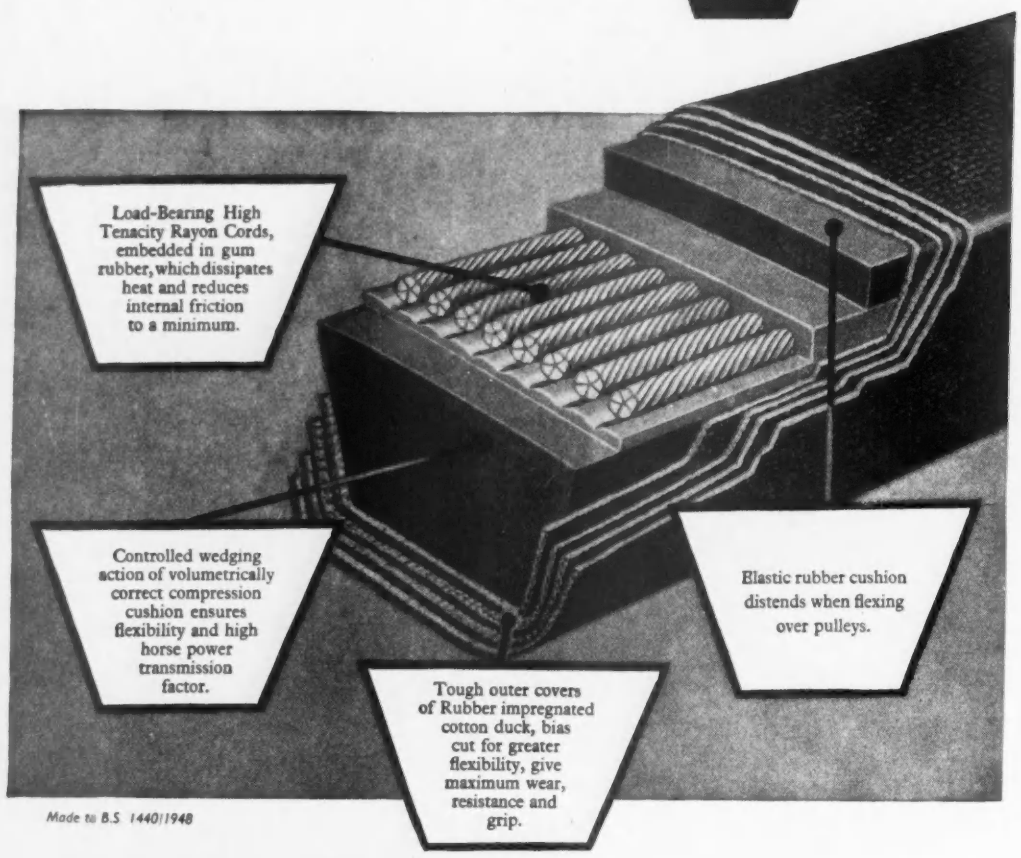
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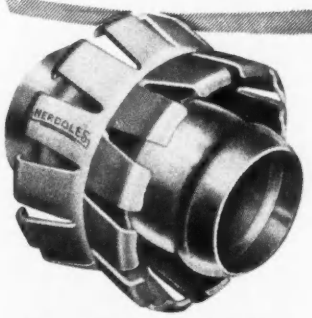

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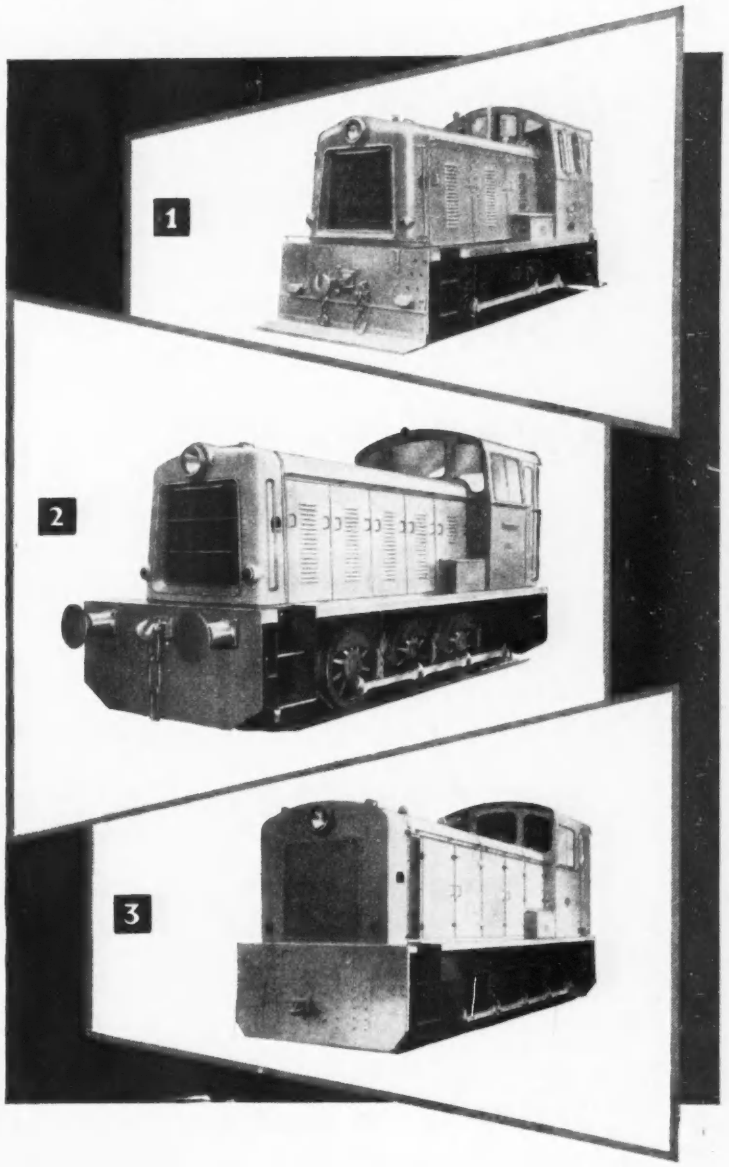

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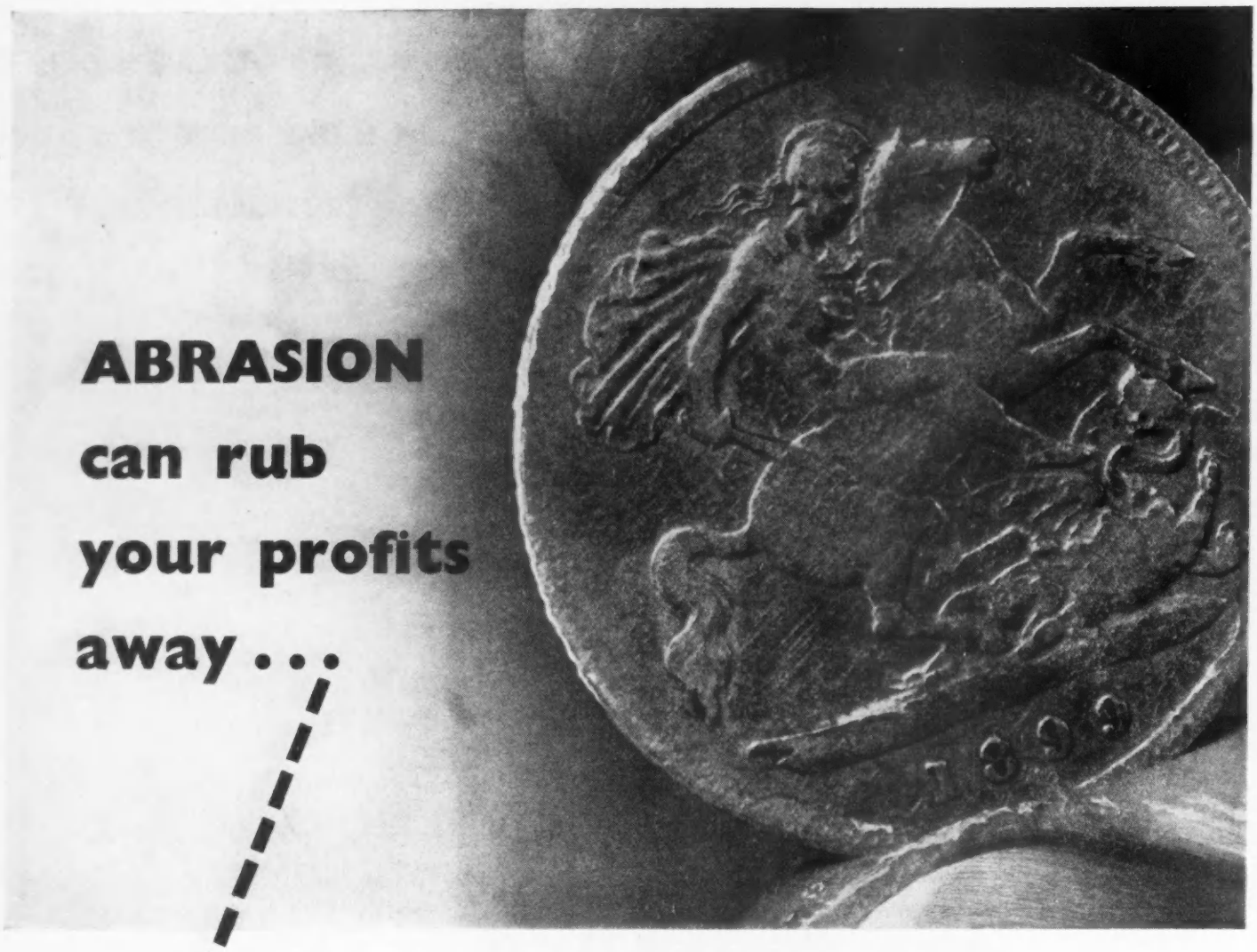

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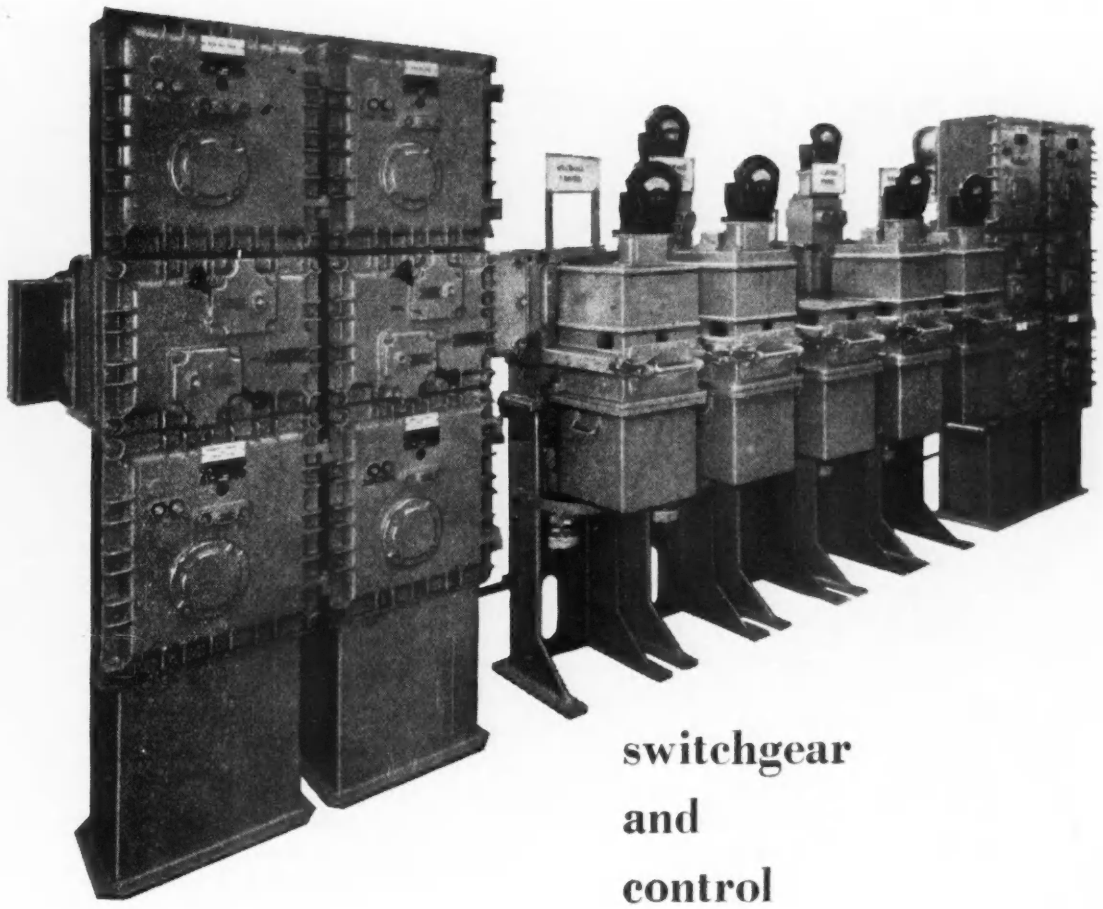

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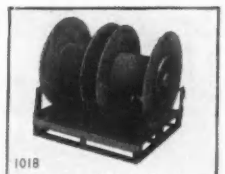

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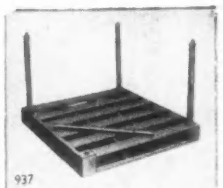

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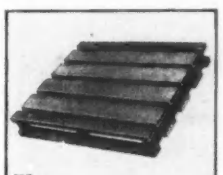

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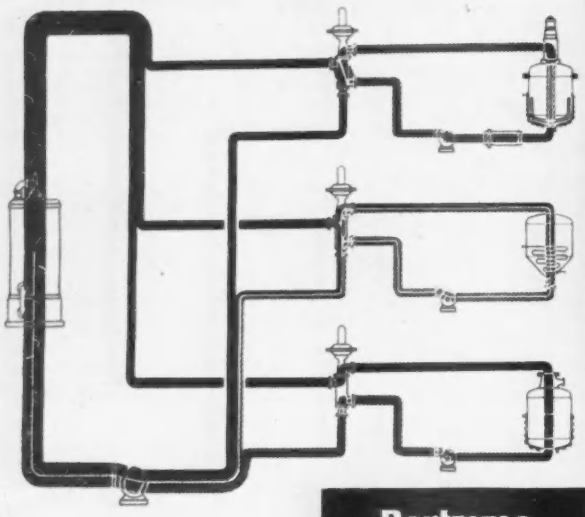

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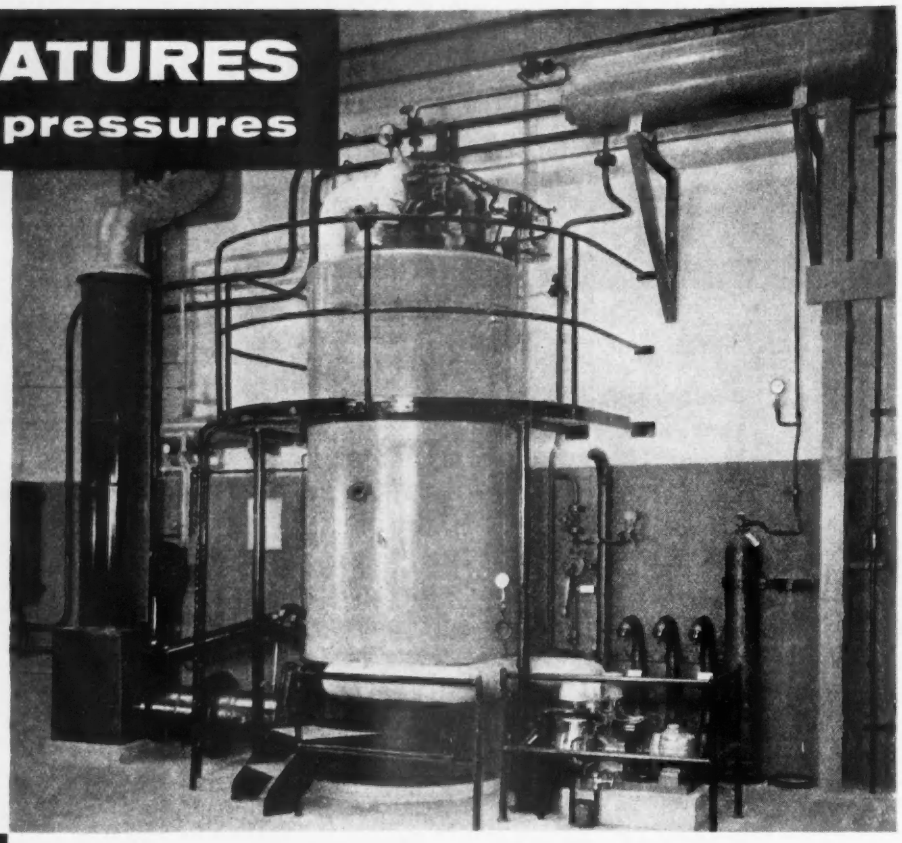

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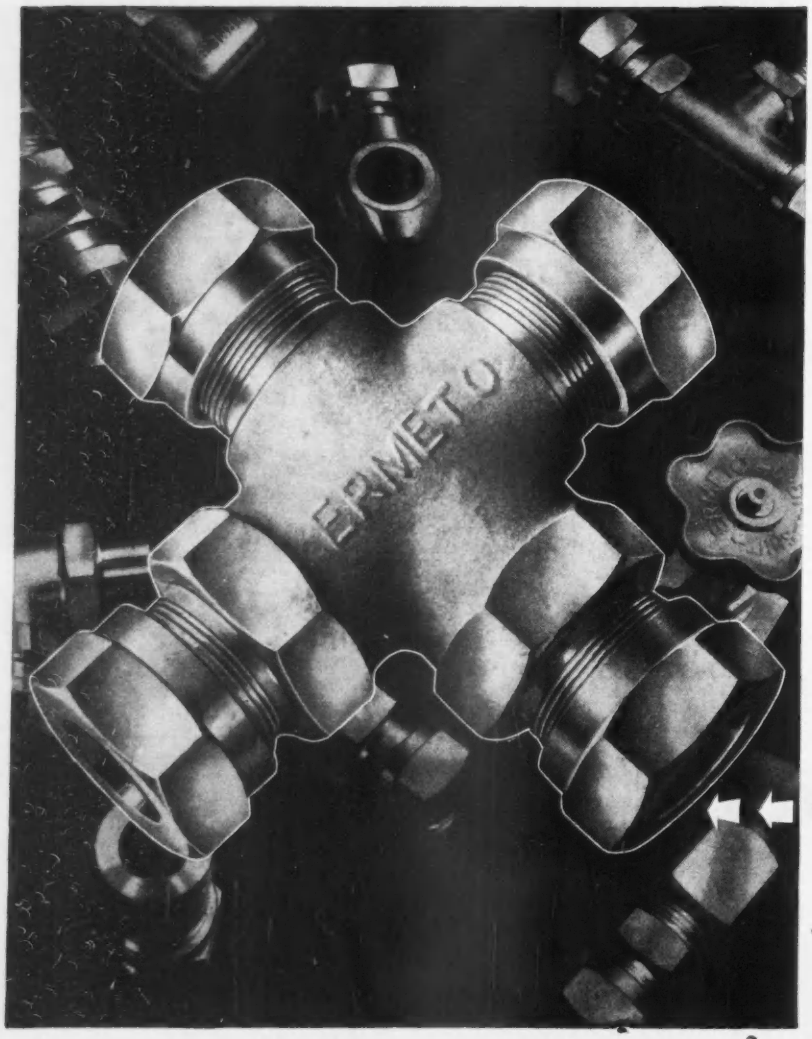

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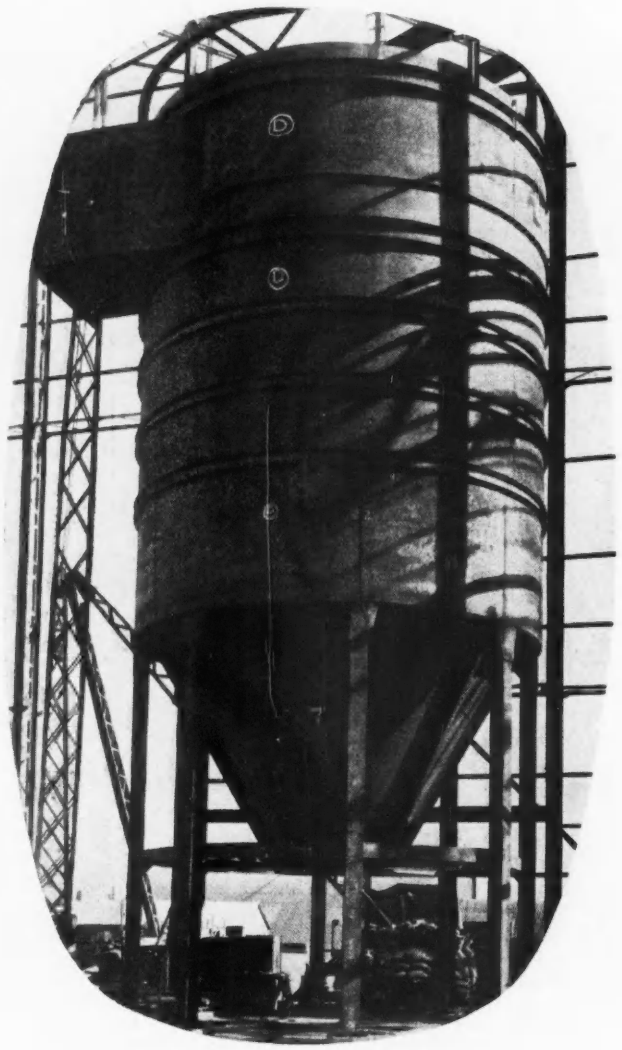

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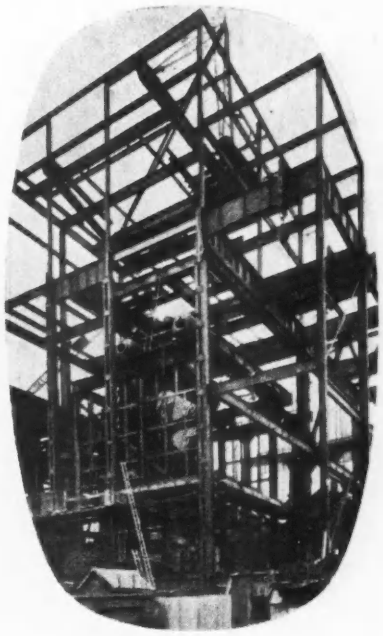

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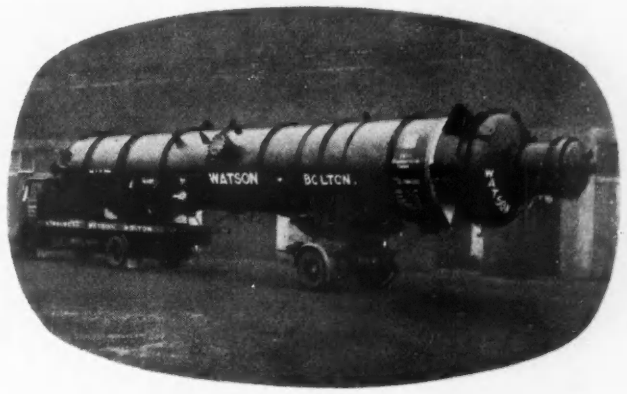

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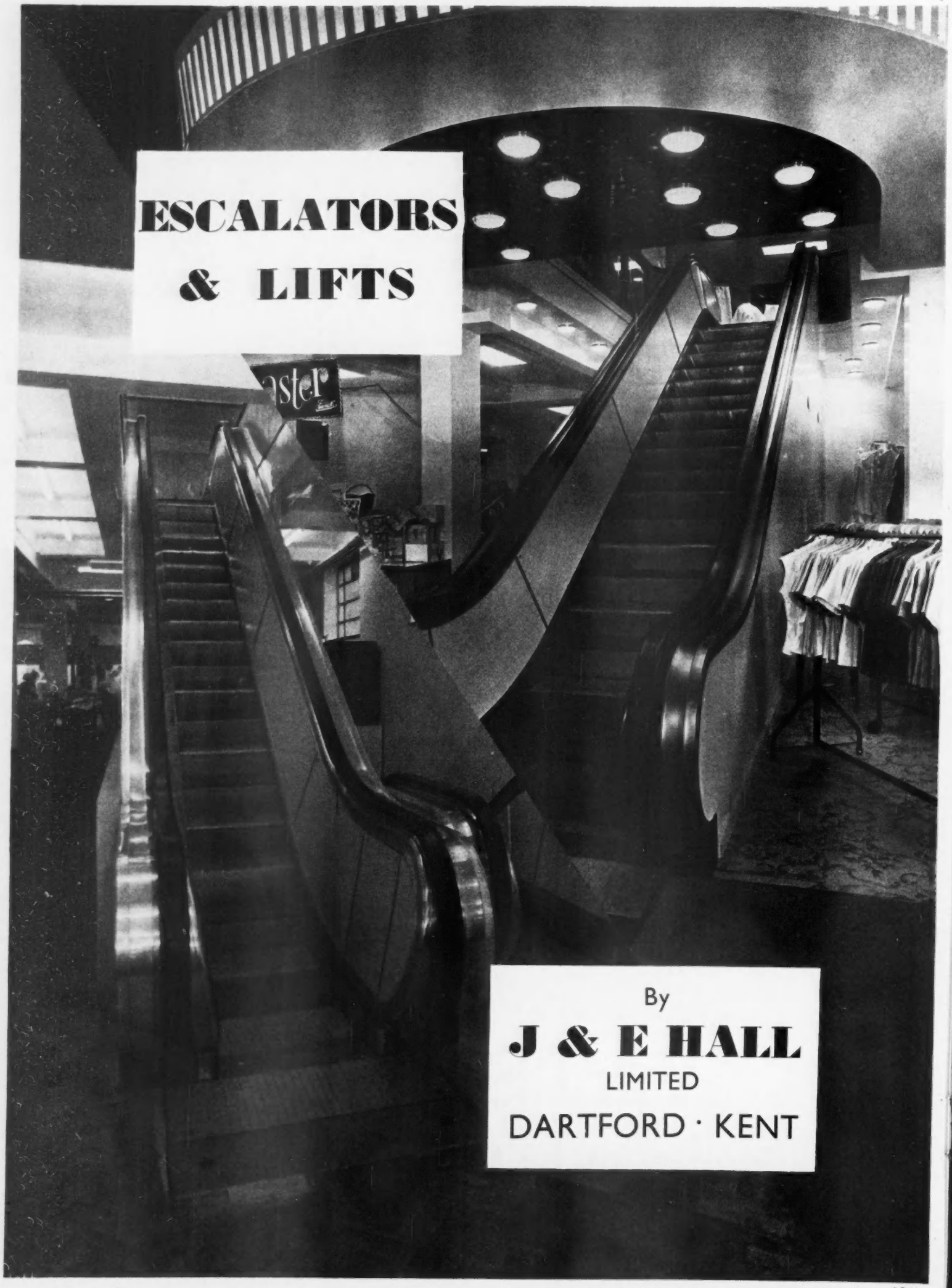
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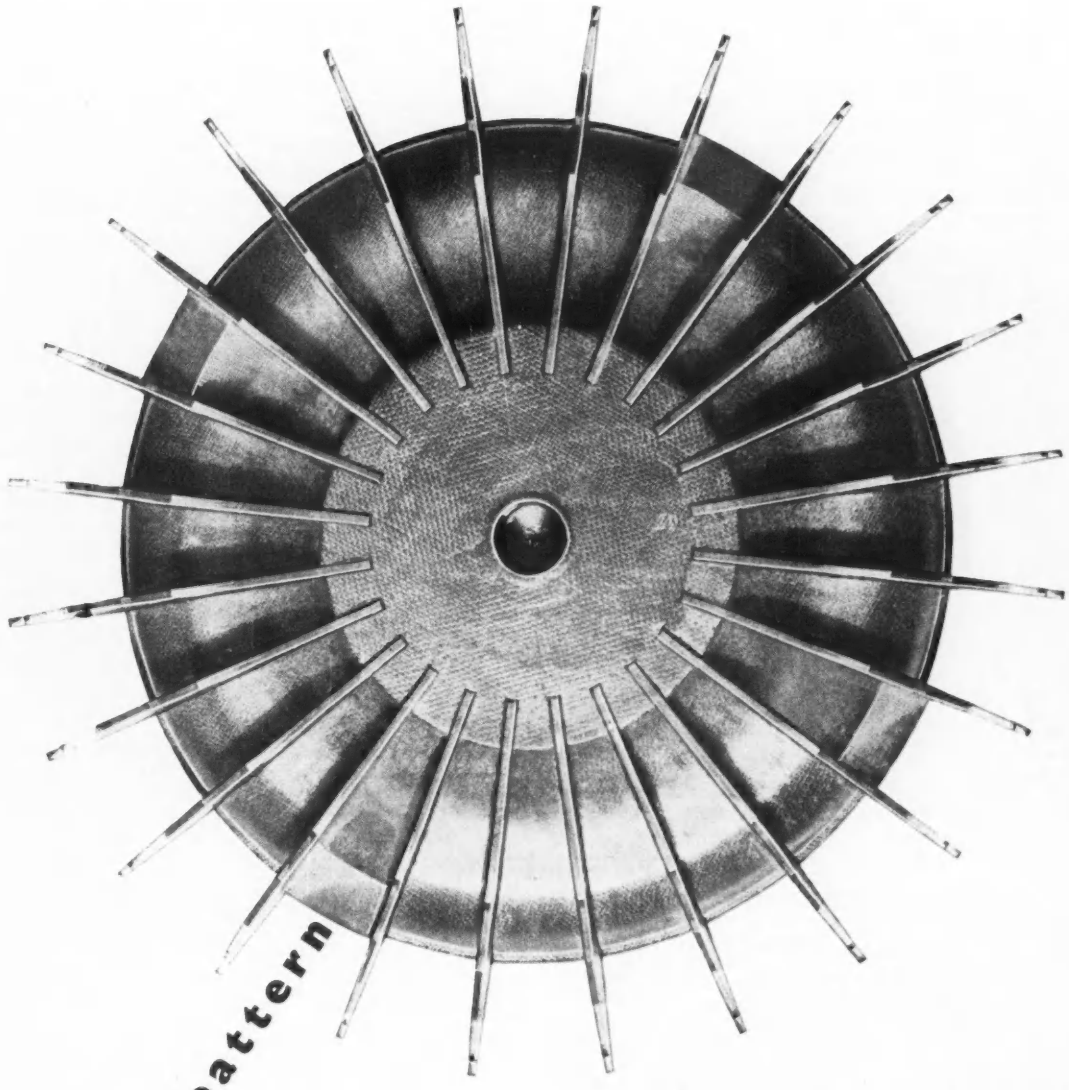

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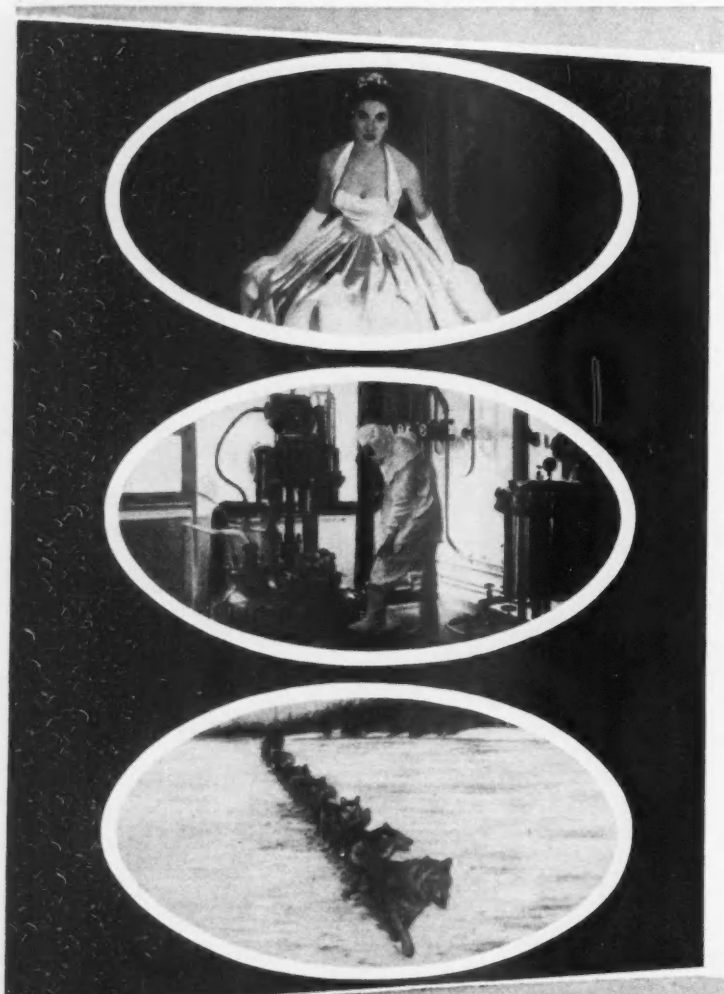

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THE ENGINEER

No. 5334 APRIL 18, 1958 VOL. 205

PROSPECTS OF NUCLEAR POWER

A very successful conference on nuclear energy was held at Eastbourne at the end of last week. It was an unusual conference in that although most of those who attended were engineers it was not really technical. The conference was organised by the Federation of British Industries to give about 100 industrialists of director status the opportunity to hear men from the Atomic Energy Authority and from nuclear power firms present papers on a number of aspects of nuclear power. For the Federation rightly felt that there was much confusion in the minds of men in industry about the future prospects of the nuclear power industry. Quite a large number of firms have supplied or are supplying special products to the consortia which are building the first group of commercial nuclear power stations, and numerous industries may well benefit by consuming some of the products of the nuclear industry, such as radioactive isotopes. How rapidly can the industry be expected to expand ? Under present plans some £750 million is being expended upon the provision of 6000MW in nuclear power stations by 1965. What hopes are there of a follow-up programme ? Can it be assumed that a great export business will be built up ? Or is it more reasonable to be cautious ? Has the designed power output of a single reactor so much increased since Calder Hall was designed that the doubt is reasonable whether there will be sufficient orders to keep all four of the existing consortia busy ? These were the kinds of questions that the conference was designed to elucidate. As Sir Claude Gibb remarked in opening the conference, there is a certain glamour about nuclear energy. What the conference was intended to do was to provide a more balanced view of the real prospects of the nuclear industry. It was intended to reveal the reality behind the glamour.

Did the conference give those who attended it a more balanced view ? We wonder. Speaking for ourselves alone, we certainly came away from it better informed than when we arrived. But we do not think we are now any the less confused than we were about the short term prospects of the industry. Unquestionably, it is right to be cautious about those prospects. It may very well be that the demand for expansion of electricity supply in this country, even if wholly borne by nuclear power, will be insufficient to keep all the consortia busy. It may well be that prospective customers upon the Continent of Europe will prefer to build nuclear power stations for themselves, merely calling upon Britain for " know-how " and perhaps certain more specialised parts. It may be right that markets in undeveloped parts of the world are more limited than one might suppose. For there is always the difficulty of getting people of sufficiently high technical quality to run such a station to stay in such regions. It may also be a fact that the gas-cooled reactor is inherently only economic when built in units of such high powers that they are suitable only for highly industrialised communities and have therefore only very limited markets abroad. It may be that in some of these prospective markets fuel is much cheaper than in Britain and capital in even shorter supply, thus rendering nuclear power uneconomic. Nobody yet knows for certain that all or any of these more gloomy prognostications will come true in the short run. But what does seem excitingly certain is that they cannot wholly be true in the longer run. Here reference can be appropriately made to a stimulating paper presented at the conference by Mr. E. F. Schumacher, Economic Adviser to the National Coal Board. He pointed out that demands for fossil fuels have been increasing for the last 100 years at about $3\frac{1}{4}$ per cent compound per annum, as man—particularly Western man—has developed ever-higher materialistic standards of living. Mere arithmetic indicates the impossibility within a relatively short span of years that stocks of fossil fuels could continue to support such an exponential growth in demand. It may be that Mr. Schumacher is unnecessarily pessimistic in accepting present-day estimates of total stocks, particularly of oil fuel, as more or less truthful, and therefore arrives at a time only fifty to sixty years in the future as that at which those stocks must be exhausted. But the nature of an exponential curve is such that the size of the stocks matters relatively little. If the world continues to demand an increase in oil supplies at an annual rate of, say, $3\frac{1}{2}$ per cent compound! (something closer to 6 per cent is more likely to be true) then every doubling of the assumed stocks only adds some twenty-five years to the period before they become exhausted. If Mr. Schumacher is right (and because of the nature of an exponential curve it is hardly possible to believe that he is very far wrong) then there is undoubtedly in the longer term going to be a very large market indeed for nuclear power stations. In fact, if limited stocks of oil are to be reserved, as sooner or later they will need to be, for use for purposes for which only liquid fuels are suitable, and the whole of the world's peoples are to continue to strive to reach American material standards of life, the prospective world-wide demand for nuclear power becomes immense. In such circumstances, as Sir Claude Gibb stressed in a speech at the conference dinner, it will be for Great Britain a matter of survival as a great industrial nation that we must develop nuclear power. It may well be true that it is equally a matter of survival for Europe as a whole ; for that Continent is distinctive, as Mr. Schumacher pointed out, in being both highly industrialised and increasingly dependent, since indigenous resources are already insufficient, upon the import of coal and more particularly oil fuel.

Of course, there was much more discussed at the conference than the prospects, alone, of nuclear power. For those who attended wanted also to gain a broad conception of the kinds of plant used in nuclear engineering and the kinds of use that new materials produced by or for the nuclear industry could be put to. Thus, there were papers on reactor types, on new materials for

nuclear engineering, on reactor instrumentation, on the fabrication and processing of fuel elements, and upon radio isotopes and their uses. From the first two of these papers it emerged strongly how much metallurgy is a limiting factor in engineering design ; from the last what a wonderful new research and inspection tool has been put in the hands of engineers now that a wide variety of isotopes has become available. The author of this isotopes paper quoted Dr. Libby, of the U.S.A.E.C., as stating his opinion that the use of such isotopes was saving industry in the United States some 406 million dollars per annum ! But basically those who attended the conference were interested in the prospects for nuclear power and particularly of nuclear power generated in gas-cooled reactors. Some interest was, indeed, shown in other types of reactor. But Sir Claude Gibb felt able to stress that for this country concentration on the gas-cooled reactor was the right course. Those present at the conference, he said, should not allow themselves to be led " up the garden path " by the success of the " Nautilus " and other American nuclear-powered submarines. The pressurised water-cooled reactor was not at present a commercial proposition. Since there was a shortage of research men in this country, we should concentrate upon improving a reactor known already to be competitive with fuel-fired stations.

The impression created by the conference was that though there may be some uncertainty about the prospects of the nuclear energy consortia obtaining even sufficient orders to keep all of them properly active in the years more immediately ahead, the more distant future is very bright indeed. Yet it did seem to us that some things which might have been more fully discussed were treated somewhat cavalierly. We know of at least one firm in this country that would enthusiastically enter the nuclear field if only there existed a nuclear power generator able to generate a moderate amount of power economically. The scope for selling power stations generating megawatts in hundreds is certainly limited ; but that for selling stations generating kilowatts in hundreds is very wide. The situation, in fact, upon a different scale, is similar to that which existed after Watt had invented the separate condenser and proved his rotatory engine an economic proposition for providing whole factories with power. There was still needed a smaller engine capable of driving individual machines. Eventually, Trevithick provided it with his high-pressure engine. We need now the equivalent in nuclear power of Trevithick's high-pressure engine. Let us concentrate mainly, as Sir Claude suggests, upon improving the gas-cooled reactor. That is wise. But we hope that neither the Atomic Energy Authority nor industry will wholly neglect research which might lead to the building of reactors able to generate hundreds of kilowatts rather than hundreds of megawatts. Will ZETA, we wonder, turn out to be the equivalent of Trevithick's high-pressure engine ?

PRACTICAL TRAINING OF ENGINEERS

There has just been issued by the Institution of Mechanical Engineers a " Report on Practical Training " by a " Committee appointed by the Council." For the most part it is an unexceptionable document. But in one recommendation we think it will be found to be highly controversial. Possibly the Council agrees with us in thinking it will prove controversial. For instead of at once accepting and adopting the document as expressing institution policy, it has preferred to issue it to many people directly concerned with its subject and to the Press in the hope that further comment will be received. The report stresses that some practical training is essential for all mechanical engineers, that part of this should be taught properly rather than acquired in a haphazard manner and that the remaining part should be sufficiently flexible to be adaptable to the desires and needs of the young engineer involved. The committee envisages differing lengths of training in different departments for men intending to specialise later in life in manufacture, in design and development, in commercial departments, upon operation and maintenance, and upon research. But whatever the final specialisation is to be it is suggested that practical training should extend over a period of two years (as compared with the Council's present practice of accepting eighteen months in mechanical engineering workshops in industry as sufficient), and that it should begin with a period of six months of basic training. It is this latter suggestion in conjunction with the lengthened period of practical training that may prove controversial. For the basic training recommended is of such a kind that it suggests that no one can become a professional mechanical engineer who is incapable of acquiring at least some measure of handicraft skill. Many young men of high academic attainments and some at least of the professors who taught them will, we suggest, utterly reject such a conception as false and intolerable.

Our late nineteenth century engineering forefathers set no great store by theoretical knowledge, for in their day engineering was far more an art than a science. To them what was really essential in anyone aspiring to become an engineer was the ability to acquire handicraft skill by years of practical experience. The art of engineering was something to be handed down from father to son. A document showing with whom and for how long one had been bound apprentice was more highly valued by most men than an academic qualification. To become an engineer one must in those days have been prepared to serve an apprenticeship of five or six years, followed (by the keener young fellows) by a couple of years or so as an improver. Very fine engineers the system produced, too ! But, in the half-century and more that has since passed by, it has become increasingly academic ability which is the distinguishing mark of a professional engineer, and nowadays even three years at university or college (or its equivalent in a sandwich course) is regarded as providing barely sufficient time for the acquirement of theoretical ability. Many educationists would like to see the period extended to four years. As a natural consequence, consciously and to some extent, we suspect, unconsciously, the major engineering institutions, now regarded by the majority of young men as qualifying bodies, have been reducing the period of practical training which they will accept as " sufficient practical experience " to permit an applicant to be elected to corporate membership. All are now taking also a much keener interest in the nature of the practical training received. No one doubts that some practical training is still essential ; nor can anyone seriously doubt that, because so much less time can be devoted to practical training, it should be more carefully planned than heretofore and that, once a young man has decided where his interests are especially going to lie, the training should be adapted to the job he intends to do. But is it now any longer a necessary part of that training that a budding professional engineer should, whether he has any desire to do so or not, acquire some degree of handicraft skill ?

Under the proposals of the committee all kinds of youngsters hoping to qualify as professional mechanical

engineers would be required to undertake at least six months' " basic " training, preferably in a special training workshop under a skilled instructor in bench work, turning, milling, grinding, foundry work, metal forming, &c., making what would be, in effect, test pieces. But is not such a requirement a survival from the past? Do all professional engineers, as distinct from apprentices to skilled trades, really need to experience such basic training ? Is it really essential in this days that all of them shall acquire a little skill in using hand tools and machine tools ? They cannot, in the time available, acquire much skill. Supposing a youngster turns out quite cack-handed at such exercises is he to be denied the name of engineer, despite the fact that he may prove brilliantly capable of analysing some trouble experienced in the test bay or capable of suggesting revolutionary improvements in the layout of a shop for greater production ? Does not this insistence on trying to make a youngster " good with his hands " make nonsense of the Institution's preaching to schoolmasters that it is their more brilliant scholars that are needed in engineering, not only those, otherwise dull-witted, who happen to enjoy making things with their hands ? Engineering to-day is at least as much a science as an art. What the committee calls basic training is essential for those who will specialise in manufacture and possibly for those to be concerned with operation and maintenance. It is merely desirable for designers ; and it seems quite inessential for those going to the commercial side or to research. Many young engineers, we believe, will nevertheless want to experience these things and to acquire some of these skills. But we very much doubt nowadays whether their acquirement is really basic to a professional mechanical engineering training. What the committee regards as basic training might well prove a waste of time to young men of good academic attainments who would gain much more valuable experience in other departments of the works, more particularly those (such as a test bay) where they could use their academic knowledge to further practical advances.

A "TIDDLEY" BUDGET

No one expected that the Chancellor of the Exchequer would announce substantial tax changes in the Budget which he opened before Parliament last Tuesday. Indeed, the more pessimistic economists predicted a no-change Budget, believing that the Government would wish to maintain its deflationary fight against the price-wage spiral unless and until there was real evidence that the recession in America was spreading across the world. Other economists suggested that he might be able to reduce taxation by some £200 million a year and that he would take the opportunity to relieve taxation in ways particularly likely to cut down the cost of living. In fact, Mr. Heathcoat Amory has produced a Budget in which tax reliefs amount only to £108 million in a full year and which in other respects may be described as a tidying one.

On the industrial side, the major change is that profits tax is to be levied at the single rate of 10 per cent as from April 1, 1958. The distinction for taxation purposes between distributed and undistributed profits is thereby removed, with a substantial simplification of accounting. A degree of political courage has been demanded of the Chancellor in making this change. For socialists will certainly claim that it is directly encouraging firms to distribute profits as dividends, and to some people there is something vaguely improper if not actually immoral about deriving an income from dividends. Somewhat unexpectedly, the Chancellor has made another change of direct interest to industry. Although credit restriction is not to be relaxed, the present initial allowances for depreciation are to be increased by one-quarter, so that they become 25 per cent for plant and machinery and 12½ per cent for industrial building. Probably the Chancellor is taking into account here the length of time that passes before a change of this character has any effects upon the economy and he is looking to a period eighteen months to two years ahead when it may, he hopes, be expected that credit restrictions will have been relaxed. One further matter affecting industry needs to be noticed. The Government has instructed the Capital Issues Committee and the banks not to hold back credit or finance for sound developments to be made in areas of this country in which pockets of substantial unemployment have recently appeared. It is unlikely, we suppose, that firms which had not contemplated the setting up of works in these areas will thereby be attracted to them ; but at least there will be less delay in starting work by those who had already planned developments in such areas. Additionally, the Government is to take powers to give financial assistance to developments in those regions and the Chancellor was also able to announce that the Government would make finance available towards the construction of dry docks in certain development areas in order to obviate the risk that a shortage might develop of docks capable of accommodating, in particular, large tankers now being built.

For the rest, apart from a number of minor proposals intended rather to tidy up or to right inconsistencies and anomalies, the major change relates to a simplification and to some extent a general reduction of purchase tax. The present seven differing rates are reduced to only four, 5 per cent, 15 per cent, 30 per cent, and 60 per cent. However, we have no doubt that Mr. Nabarro will still be able to find anomalies with which to tease the Chancellor. Yet there is a good deal of merit in Mr. Heathcoat Amory's contention that it would be impracticable, at least on present levels of taxation, to substitute a Sales Tax.

The Engineer— 100 Years Ago (APRIL 16, 1858)

" METALS "

" The metal market, contrary to all anticipations, continues very depressed. RAILS—The large order for Russia of about 40,000 tons it was expected would have had considerable effects upon the market, and higher rates would rule, but most of the leading makers are still short of orders, and £6 per ton is the nearest quotation for an ordinary rail f.o.b. at the Welsh ports. Fishing pieces, £7 10s. ; wrought iron chairs, £7 10s. ; and cast chairs, £4 5s. per ton.

" SCOTCH PIG IRON—The rapid fall from 60s. to 53s. has been caused principally by some weak speculators being unable to hold. The shipments during the past six weeks have been unprecedentedly large, although the home consumption has fallen off to a great extent. The shipments for the week ending the 14th inst were 10,500 tons against 13,900 tons the corresponding period last year. The stock on warrants is about 95,000 tons.

WELSH BAR IRON—Cargoes of first brands can be purchased at £6 per ton at Cardiff or Newport ; secondary brands at £5 15s. per ton.

" SPELTER is dull of sale, £26 5s. is quoted on the spot. The stock is about 1,700 tons against 1,200 tons corresponding date last year.

" COPPER—There is only a very limited business ; shippers and consumers are looking for a further reduction, although the present price of copper ore leaves but little profit, if any, to the smelter.

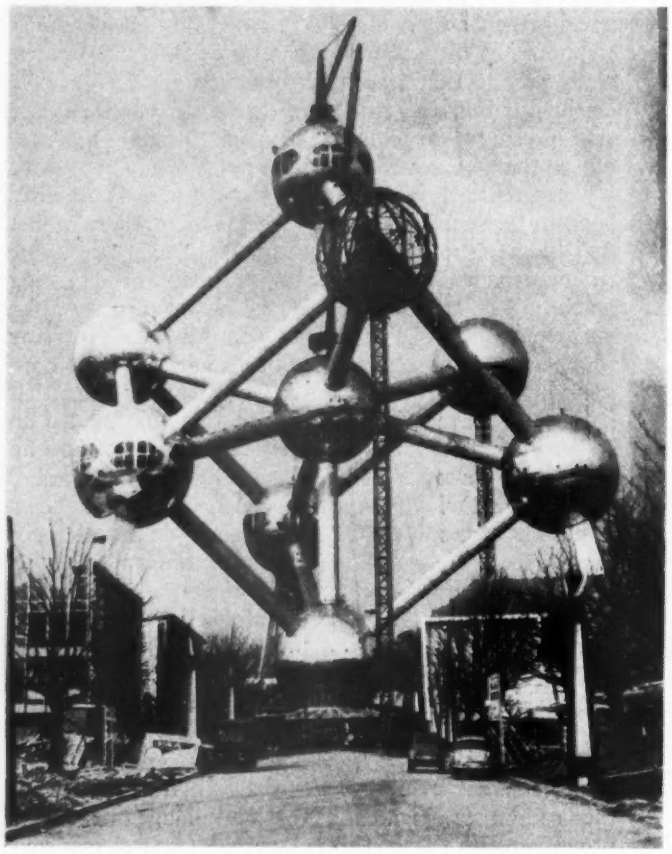
" LEAD—The demand has fallen off, especially for the home trade. There are a few parcels of fine soft Spanish on the market.

" TIN—The rapid fall in this article has had but little effect upon the demand. Banca is now quoted at £112, and fine Straits at £110 per ton ; the stock is increasing.

" TIN PLATES have sympathised with tin, and good brands of coke can be purchased at 25s. per box at Newport, and charcoal 31s."

INTERNATIONAL & UNIVERSAL EXHIBITION —BRUSSELS 1958

No. I



DURING the last century, thirty World Exhibitions have been held, beginning with the Great Exhibition in London in 1851. Thirty-four years later came Belgium's turn with Exhibitions in Antwerp (1885, 1894 and 1930), Liège (1905 and 1930), Ghent (1913) and Brussels (1888, 1897, 1910 and 1935). The last fair to be held was the New York World Exhibition of 1939. After an interval of 19 years, the 31st International and Universal Exhibition opened in Brussels on April 17, and will remain open to visitors from all over the world until October 19. Sited on an area of 200 hectares—one-third the size of Brussels and 1½ times that of Hyde Park—the Exhibition is an event which according to the 1928 Agreement cannot be repeated in Europe for at least six years. Our article describes the fair, in which Great Britain is taking a prominent part. The general theme is "A Balance Sheet for a More Human World," and besides the Belgian and Foreign Sections, there is for the first time an International Section representing the important international bodies which have come so much to the fore in recent years. The Exhibition is dominated by the Atomium, a spectacular structure 350 ft high carrying nine aluminium-covered spheres 18m in diameter. The five lower spheres house exhibitions on the theme: "Atomic Energy for Peaceful Purposes."

YESTERDAY, April 17, the International and Universal Exhibition, Brussels, 1958, opened its gates to the public. From now until the closing day, October 19, and particularly during the coming holiday season, Brussels will form a centre of attraction for visitors from all parts of Europe and overseas. Forecasts mention figures in the region of 35,000,000 ; a very large number, indeed, when it is remembered that the total population of Belgium is about 11,000,000. Most of the visitors, apart from the people of Brussels itself and from other parts of the country, will no doubt come from Belgium's neighbours, the Netherlands, the German Federal Republic, Luxembourg and France, as well as a considerable section from the United Kingdom. Not all of them will stay in Brussels itself ; many will prefer to find accommodation in the various provincial centres, such as Bruges, Ghent, Liège, Namur, Antwerp, Mons and Tournai, with their many historical associations and tourist attractions, or they will stay at the seaside or inland, in the valley of the Meuse or in the Ardennes, and from those places travel to Brussels on day trips, since by the fast train and bus services available any part of Belgium is within easy reach of the capital.

Many provincial Belgian towns are arranging celebrations and festival weeks of their own, and these, with their strong accent on local custom and ancient tradition, should prove of particular interest to foreigners. Several technical and scientific congresses will also be held either in Belgium itself or in neighbouring centres, with visits to the Fair incorporated in their programme.

The 1958 Universal and International Exhibition is not intended to be a trade or industrial fair, but to be primarily an occasion where the nations can parade their achievements in all spheres of human activity, whether technical, scientific, or cultural, and to show to one another's members something of their individual ways of life. The interdependence of the modern world is stressed by the participation, for the first time, of such bodies as the United Nations, the European Coal and Steel Community, the O.E.E.C., the Council of Europe, and others. In the words of the Belgian Commissioner General, Baron Moens de Fernig :

"The speed and diversity of modern methods of communication have reduced distances and brought people together. Considerable increases in power potential, coupled with a constantly advancing technique, in certain countries, have brought higher standards of living within the reach of large numbers of people.

"These same factors increase the future material possibilities for humanity, but there are also problems in these hopes for the future.

"It is therefore appropriate that each person and nation should come to realise their common tasks for the future. World co-operation becomes an absolute necessity. The yardstick of the future may no longer be marked in purely local or national scales. If real peace is to be achieved then there must be an intimate and positive understanding between peoples. This understanding can result only from each and every person knowing and understanding themselves better.

"The Universal and International Exhibition of 1958 sets out to provide the opportunity for men of all races to come to grips with these problems. In addition, due to the theme running through all its sections, it seeks to have a profound influence upon our own era.

"We consider that this theme is the principal aspect of the 1958 Exhibition and as such we have thought it right that it should be widely known."

The theme of the "Brussels, 1958" Exhibition is "A Balance Sheet for a More Human World." As Monsieur Ch. Everarts de Velp, the Secretary General, says : "To summarise any one age is bound to be difficult and this age is certainly no exception —indeed, it may well claim to be the most astounding and paradoxical in human history. Its problems are without coherence and each day brings amendments to new-found solutions and truths. Man finds himself in a universe which he is tempted to declare irrational. This very situation should be the inspiration to spare no effort on behalf of the human spirit. . . . The 1958 Exhibition . . . seeks to break new ground by facing up to all the difficulties of life in this modern age and by refusing to gloss over the exacting demands made by the search for truth. We want to draw up a balance sheet of all human activities, to help people bring a sharpened and dynamic realisation to their obligations. We want to be able to suggest in a realistic and concrete manner, the way in which these obligations may be met. The pressing urgency of the situation follows from the nature of the development of our world. An analysis of this evolution enables us to see the basic problem which faces mankind to-day. Nobody can deny that our age is dominated by scientific and technical progress. In many countries 'spiritual authority' has given place to scientific authority and its technical applications. We find that deep disturbances in social, geopolitical and psychological spheres have followed an accelerated scientific evolution. The task is to find the means by which a balancing adjustment may be made.

The scientific and technical discoveries of the last fifty years have disposed of the isolationist political doctrines of yesterday and yet, paradoxically, the solitude of man increases in a world where, if logical reasoning held good, such advances would tend to provide closer and more fruitful contacts. Whether they like it or not, nations have to admit that the most realistic policy is the very one which at the turn of the century seemed to be the most foolish. Modern facts force nations to accept the fundamental movements of our times where divisions appear as distortions of human outlook. The causes of this profound transformation have been : the progress of science ; the extraordinary development in techniques of spreading information, and the speeding up of transport.

" No one nation to-day has a monopoly of scientific progress. Furthermore, the specialisation within the different scientific fields calls for a continuous exchange of ideas and information throughout the world. Science to-day is really international : the tools it uses—even its language—are not the prerogative of any one people. The same development may be seen in the economic field. The international exchange of power over thousands of miles has changed the industrial geography of entire continents. We are witnesses of an economic redistribution which pays more attention to the rules of logic than of frontiers and nationalism. In the production field, the shift of emphasis is apparent : only those industries which are able to work to full production and on a large scale are in keeping with the times.

" The effects of the increase in the speed of transport systems are even more obvious. Distance is no longer measured in miles or kilometres but in time. Thanks to the aeroplane, Brussels is now much nearer to Tokyo than it was to Paris a century ago.

" Added contributions to this breaking down of barriers have been made by the advances in techniques of providing information .... The ultimate consequences of these advances cannot be predicted. Yet it may be said that in spite of the obvious advantages provided for modern life the progress already achieved has not yet produced a spiritual rapprochement between men. The solitude of man has never been greater. The rate of discovery has produced the situation where man can no longer find the time to profit from the means at his disposal for knowing and understanding his neighbours.

" For thousands of years we have relied upon physical effort and now in the space of approximately one hundred years the sources of energy have multiplied : steam, electricity, nuclear energy. This progression has provided better and quicker production at a saving of physical effort—and the advent of automation will make this evolution even more rapid. In the electronic factory of tomorrow, the human factor in the production line will disappear.

" The prospect of humanity no longer working to survive but simply in order to live a balanced and human life must now be accepted. Man must learn how to profit with discrimination from the leisure time created by this liberation from physical labour. We are far from this knowledge at the moment.

" The more progress we make towards this liberation and the extension of our leisure, the more we work to quicken the process of scientific discovery and its technical application.

" In addition, specialisation increases to a degree. In all spheres of activity we are led to devote more and more time to our own particular subject. In an age where productivity is the order of the day, we ought to rediscover the ability to ' waste time ' intelligently. When we do manage to spare time for reflection, our meditations lead us to the conclusion that we are closer to the keys of the future than ever before. Yet with this knowledge we feel a certain anxiety —an anxiety which is fully justified. What other feeling can we have when we know that 1500 million human beings out of a total world population of 2500 million are living at starvation level, while the means of production now at our disposal would enable us to meet demands at a level even higher than these circumstances call for ?

" How can we fail to be bewildered when we know that as a result of the scientific discoveries in the battle against disease and illness, the world population will have increased to 3500 million in twenty-five years ?

" Uneasiness must follow from our inability to keep in touch with the urgent problems of our time while the rest of humanity becomes increasingly foreign to us as we concentrate upon our own particular fields of activity. Nicholas Berdiaeff has put his finger exactly on the drama of our age : ' The great victories achieved by mankind in the realm of science have become the principal source of dehumanisation in human life. Man is not yet master of the machine which he has invented.'

" This is the paradox which faces our generation : we hold all keys and yet we lack the knowledge which will enable us to open the door of the future. We have automation and nuclear power. We are witnesses of daily scientific discoveries. We are able to benefit from a potential leisure which would have been undreamed of fifty years ago. We possess the finest instruments of knowledge and culture. Yet, in spite of all these—or perhaps because of them—we are unable to protect ourselves from a very real fear. As Protagoras would have said, we are no longer ' within the limits of things.'

" We know that all civilisations are mortal and that by a strange paradox of history they are particularly vulnerable at the precise moment when they are on the point of achieving their greatest glory. Yet we can take heart in the fact that millions of people are deeply aware of the crisis facing the modern world and seek to disengage the forces of this evolution and to find a new humanism suited to the realities and requirements of this generation.

" The 1958 Exhibition seeks to mirror these aspirations. Naturally we do not expect it to be an immediate panacea for all the world's troubles. Indeed, this is not the aim. The main objective is to suggest the paths to be followed.

" The intention is for each nation to show, not so much what it is doing, but what it is. To show the methods it advocates for the ' rehumanisation ' of the modern world. At the same time, the Exhibition seeks to supply the crowds of visitors with a striking revelation of this world, its diversity, its future, and the dangers. The final aim is to bring these crowds to a common and active realisation of the interdependence of nations and the pressing need for material and spiritual exchanges between peoples."

Organisation

The first World Exhibition was organised in London in 1851. It was held at the Crystal Palace and brought together 17,000 exhibitors, 510 of whom were Belgian. Since then twenty-nine World Exhibitions have been held. Up to 1928 any country could organise an activity of this kind as and when it thought fit. Many of them were extremely brilliant, others were less so and were more like a huge international Fair than a World Exhibition.

To remedy this situation, thirty-five countries, incudling Belgium, signed a diplomatic Convention in Paris on November 22, 1928, to regulate the frequency and method of organisation of World Exhibitions. An International Exhibition Office was set up and exhibitions were divided into two groups, viz., special exhibitions, and first or second category general exhibitions. Special exhibitions are concerned with only one branch of activity, whereas general exhibitions are not limited. If, in addition, their organisers decide to include all human activities according to the widest classification, the exhibition then becomes Universal. For first category general exhibitions, invited countries have to construct their national pavilion, the bare ground being placed at their disposal free of charge by the organising country. For second category exhibitions, the organising country must build pavilions for foreign countries at its own expense. Signatories to the Paris Convention undertook to allow six years to elapse between two consecutive first category general exhibitions. Furthermore, a country may organise only one first category exhibition in fifteen years. The 1958 Brussels Universal and International Exhibition is of this kind.

It was on May 7, 1948, that the Belgian Government, on the proposal of the Burgomaster of Brussels, decided that the capital should be the site of the next Universal and International Exhibition.

By a decree of November 17, 1951, on the proposal of the Cabinet, H.M. The King appointed Baron Moens de Fernig, a former Minister, as the Government's Commissioner General. A royal decree of May 29, 1952, published in the *Moniteur* of October 5, 1952, set out the task and powers of the Commissioner General.

On June 20, 1952, the Cabinet decided that the Exhibition would be held in 1958. At its meeting on November 5, 1953, the International Exhibition Office entered the 1958 Brussels Universal and International Exhibition as a first category exhibition.

The Exhibition is placed under the authority of the Minister of Economic Affairs, in whose name the Government Commissioner General ensures the conception, carrying out, organisation and administration of the Exhibition. Details of the work are in the hands of the Exhibition Company, which, therefore, is responsible to the Commissioner General for all works, and is directed and controlled by him.

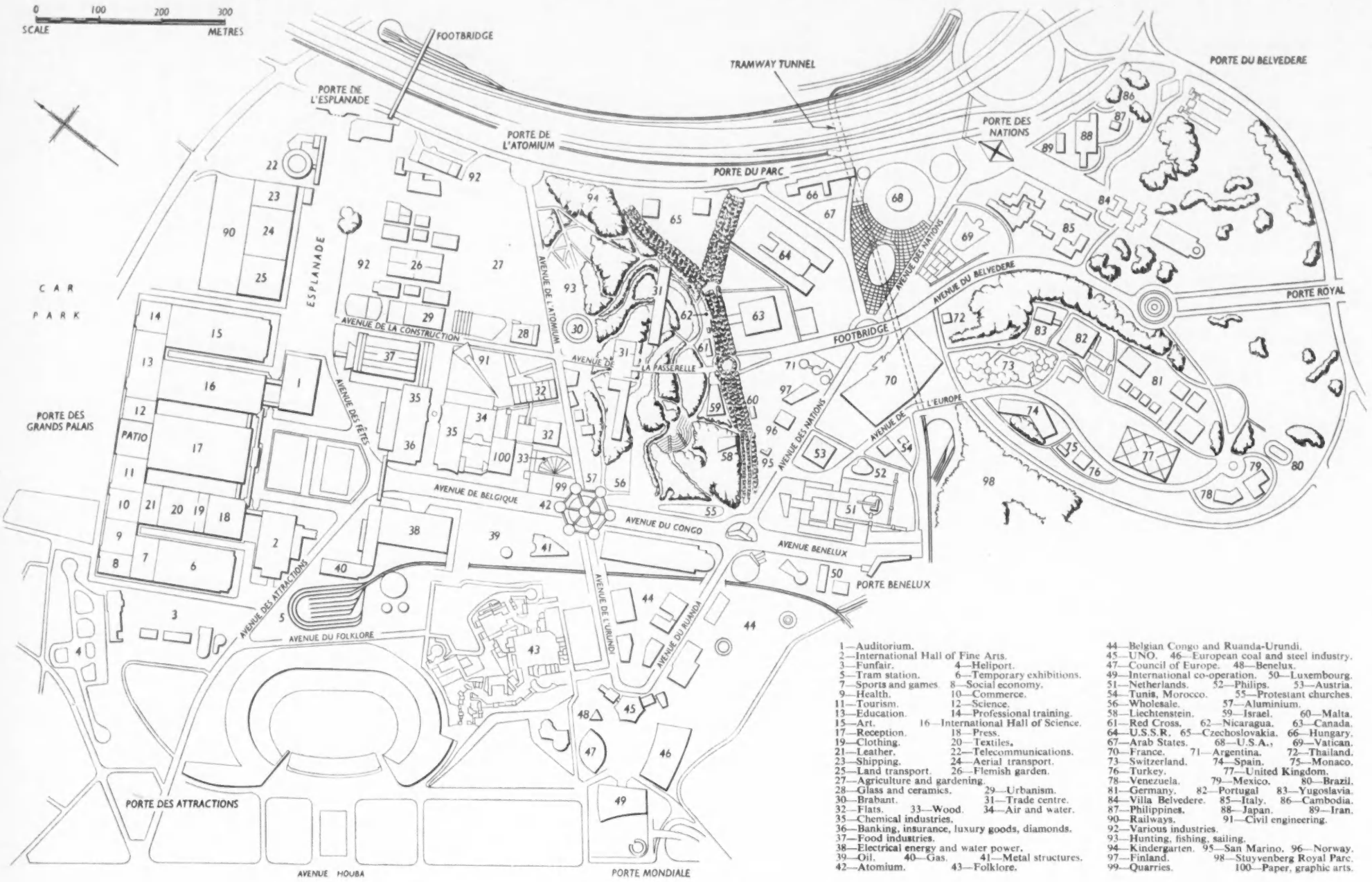
Principal Divisions

For this year's World Exhibition, a vast area of 200 hectares, or half as much again as for the Brussels World Exhibition of 1935, was placed at the disposal of the Société de l'Exposition. It comprises the Exhibition grounds at the Heysel, a few kilometres to the north-west of the centre of Brussels, together with Osseghem Park in the centre and a portion of the adjoining Royal Park of Laeken, including the Villa Belvedere, which has been made the official residence of the Commissioner General.

In broad outline, the Exhibition will consist of a Belgian Section, a Belgian Congo and Ruanda-Urundi Section, the Foreign Sections, and the International Sections. A plan of the Exhibition is shown in our illustration (page 566).

The Belgian Section covers an area of 112 acres, and includes forty-six out of the fifty-two groups in the General Classification,

INTERNATIONAL AND UNIVERSAL EXHIBITION—BRUSSELS, 1958



1—Auditorium.
2—International Hall of Fine Arts.
3—Funfair. 4—Heliport.
5—Tram station. 6—Temporary exhibitions.
7—Sports and games. 8—Social economy.
9—Health. 10—Commerce.
11—Tourism. 12—Science.
13—Education. 14—Professional training.
15—Art. 16—International Hall of Science.
17—Reception. 18—Press.
19—Clothing. 20—Textiles.
21—Leather. 22—Telecommunications.
23—Shipping. 24—Aerial transport.
25—Land transport. 26—Flemish garden.
27—Agriculture and gardening.
28—Glass and ceramics. 29—Urbanism.
30—Brabant. 31—Trade centre.
32—Flats. 33—Wood. 34—Air and water.
35—Chemical industries.
36—Banking, insurance, luxury goods, diamonds.
37—Food industries.
38—Electrical energy and water power.
39—Oil. 40—Gas. 41—Metal structures.
42—Atomium. 43—Folklore.
44—Belgian Congo and Ruanda-Urundi.
45—UNO. 46—European coal and steel industry.
47—Council of Europe. 48—Benelux.
49—International co-operation. 50—Luxembourg.
51—Netherlands. 52—Philips. 53—Austria.
54—Tunis, Morocco. 55—Protestant churches.
56—Wholesale. 57—Aluminium.
58—Liechtenstein. 59—Israel. 60—Malta.
61—Red Cross. 62—Nicaragua. 63—Canada.
64—U.S.S.R. 65—Czechoslovakia. 66—Hungary.
67—Arab States. 68—U.S.A., 69—Vatican.
70—France. 71—Argentina. 72—Thailand.
73—Switzerland. 74—Spain. 75—Monaco.
76—Turkey. 77—United Kingdom.
78—Venezuela. 79—Mexico. 80—Brazil.
81—Germany. 82—Portugal 83—Yugoslavia.
84—Villa Belvedere. 85—Italy. 86—Cambodia.
87—Philippines. 88—Japan. 89—Iran.
90—Railways. 91—Civil engineering.
92—Various industries.
93—Hunting, fishing, sailing.
94—Kindergarten. 95—San Marino. 96—Norway.
97—Finland. 98—Stuyvenberg Royal Parc.
99—Quarries. 100—Paper, graphic arts.

which corresponds to some 250 classes, or 250 human activities which will be represented from an exclusively Belgian aspect. The General Classification of the 1935 Exhibition contained only twenty-eight groups and 168 classes, which gives an idea of how human activities have extended since that time.

As the keyword of the 1958 Exhibition is humanism and the theme one which invites the peoples to get to know one another better by comparing their conceptions of life's problems, many Belgian exhibitors decided that they could best conform to this basic idea by collective presentation. The general pattern is therefore one of group representation, exhibitors exercising a similar activity forming a group in order that their presentations, taken as a whole, may represent an aspect of their nation's life capable of being compared with that of other countries. It will be seen that this is quite different from a trade fair, where each firm reserves its individual stand without any relationship with neighbouring stands. At the same time, the regulations were worded in such a way as to allow the participant to exhibit in the section of his choice, according to his own interests. A detailed classification endeavours to present all the problems in their entirety in order to give this flexibility of choice, according to the clientele of each exhibitor. For example, one manufacturer of electric heaters may prefer to figure among the electric firms, while another may prefer to show his heater as a household appliance. A group is itself subdivided into classes. For instance, the classes of the " Metallurgy and Steel Products " group include iron smelting, non-ferrous metals, foundries, wire drawing, forging, metal frames, welding, industrial tooling, applications of mechanical skill, &c. The title of exhibitor is reserved for " producers " and " publishers," i.e. those who manufacture, transform or put into circulation objects or matter of use to mankind, and the Belgian Section regulations specified that this title might be granted only to participants who undertook to occupy at least 20 square metres of floor space, thus fixing the minimum contribution of an exhibitor to the overall effort. Since not all participants were able to manage this minimum, the Belgian Section regulations allowed several participants to have a common " Joint Exhibit." In such cases, the title of exhibitor is not granted individually to each member of " Joint Exhibits," but to the " Associated Exhibitors " itself. Those exhibitors who wished to do so were able to erect a private pavilion, but only if the exhibitor also undertook to participate in an " Associated Exhibitors " Section. This condition, which may seem severe, was indispensable in order to avoid collectives being deprived of their biggest exhibitors should the latter limit their contribution to one sole private presentation. This would, of course, have been in contradiction to the theme of the Exhibition.

A foremost place is occupied in the Exhibition by the Belgian Congo and Ruanda-Urundi Section.

The conception and carrying out of the Congo Section were ensured by leading members of the colony and private sector grouped into three committees : a Committee of Honour at the head of which were the Minister for the Colonies, the Governor of the Congo and the General Administrator of the Colonies, and an Executive Committee and a Permanent Committee, both placed under the authority of Mr. Bruneel, president of the Belgian Colonial Interests Association.

In the foreign and international sections are grouped together foreign sovereign powers and the great supra-national and intergovernmental organisations, while two large international halls are devoted to Science and Art.

The following nations are exhibiting in their own pavilions :—Luxembourg, Norway, the Netherlands, the Vatican, the United States, Finland, Canada, San Marino, the United Kingdom, Yugoslavia, France, Austria, Israel, Monaco, Portugal, Czechoslovakia, Italy, Japan, Switzerland, the German Federal Republic, Liechtenstein, Hungary, Spain, Venezuela, the U.S.S.R., Turkey, Cambodia, Morocco, the Dominican Republic, Brazil, the Argentine, Nicaragua, Syria, Lebanon, Jordan, Iraq, Philippines, Iran, Mexico, Saudi Arabia, Egypt, Tunisia, Sudan, Chile, Thailand, and Laos.

International agencies include the United Nations Organisation and its specialised agencies, the Organisation for European Economic Co-operation (O.E.E.C.), the Council of Europe, BENELUX, the Council of Customs Co-operation, the International Red Cross, and the European Coal and Steel Community (E.C.S.C.).

General Planning

Work in preparation of the Exhibition fell into four main phases, the first of which ended on December 31, 1955 ; registration of exhibitors, which closed three months before, enabled the general layout to be drawn up. This phase consisted of working out the overall plans ; establishing the layout and all the elements connected therewith (roadways, water mains, electricity supply, car parks, &c.) ; setting down on paper the allotments of ground to the different countries, " Associated Exhibitors," great international organisations, Belgian exhibitors—the total space requested reached no less than 160 per cent of that available—commercial operators and amusements. Then, as an integral part of these questions, came the embellishment programme and last, not least, the problem of propaganda for the Fair. The second phase, from January 1 to September 30, 1956, was devoted to drawing up and approving plans, submitting tenders and awarding contracts. Then came the period October, 1956, to June, 1957, when building foundations were laid and main walls erected. Finally, from July, 1957 onwards, took place the completion of the buildings and their interiors and the final preparation of the gardens.

Architecture

The tasks which faced Monsieur van Goethem, the Chief Architect, who was responsible in particular for the Foreign Section, and his team, can be classified roughly under three headings : to change the road system created for the 1935 exhibition ; to connect the wooded grounds of the Osseghem and Laeken Parks by an aerial bridge on the same level, and to construct an esplanade where processions can be organised.

Before describing in broad outlines the basic plan for the Belgian Section of the 1958 Exhibition, mention must be made of the main points of the problem which the architects had to solve. The aim has been to erect halls, pavilions for associated exhibitors, exhibition concessions and commercial concessions, in an orderly manner which had to take logical and æsthetic requirements into account. The area consists of some 180 acres spread out around the group of main halls between the future Ring, the Chaussée de Meysse, the underground tramway line and—running along the Avenue de Bouchout—Osseghem Park.

As regards the architectural approach to the work, this may be defined negatively by saying that the architects wanted at all costs to avoid using the method of the 1935 Exhibition, when the Belgian Section had the appearance of a rather ill-assorted collection of pavilions. This time, on the contrary, the object has been to give the Belgian Section a unified appearance that will be evident to all visitors. Unity is achieved in a variety of ways. For the construction of the various Associated Exhibitors Halls horizontal and vertical outlines were imposed and all halls are of the same colour. This " uniformity plan " actually follows the example set by the architect Ernest Acher who, at the 1910 Solbosch Exhibition, gave the Belgian Section a unique façade of monumental aspect.

The way in which the plan has been carried into effect, however, proves that unity of mass, colour and, above all, approach, in no way means monotony. The greatest latitude was given to the architects of the halls housing the Associated Exhibitors as regards the general decoration of the work for which they will be responsible, and the choice of materials. By alternating buildings and green spaces a movement was created within the Section which enables the visitor constantly to discover new perspectives.

In the Belgian Section, instead of merely cutting the major axis of the Avenue du Centenaire by the Atomium group, it became necessary to isolate each section of this avenue so that the sections fitted in with the general effect of the group they passed through. The chief architect of the Belgian Section, Mr. Hendrickx-van den Bosch, barred the upper entrance to this avenue by a portico unifying the lateral frontages. In this way the spectator coming from the Reception Station (Hall 5) views a splendid length of frontage broken by this portico and allowing a glimpse of the pavilions of the Associated Exhibitors stretching out along the avenue as far as the Atomium. Behind these pavilions, grouped round the " Patio," are the exhibition concessions surrounding the " 4 Seasons Garden," which is dominated by the Esplanade and the foliage of Osseghem Park.

If the framework to which architects in the Belgian Section had to adhere seems a little rigid, it is because those responsible for the layout planning have wished to show that unity of form does not prevent the varied use of volumes, materials and colours, provided always that these are studied in a fluid sense and not in conventional rigidity.

The master plan intentionally imposed a certain discipline throughout the monumental perspective while leaving to each individual architect responsible for the erection of a pavilion the opportunity to show his imagination and ideas of composition.

As for the Congo Section, breaking away from the original plan, the principal architect of the section, Mr. Houyoux, has sited his pavilions according to a rhythm of volume which can be seen on all sides and is balanced against the mass of verdure of the wooded park. The planning of this section is allied to the climatic nature of the country. It is sufficient to distribute the architectural masses to avoid overcrowding.

Visitors to the Foreign Section follow a curved, but not tiring, road to reach the various sites and arrive at the aerial bridge offering a unique view over the whole of the foreign section. The planning problem here has been more complex, and involved a balancing of national architectures. The work was based on the example of Le Corbusier. Faced with the impossibility of imagining beforehand the solutions that would be put forward, it seemed imperative

to avoid severe alignments and to substitute pleasant curves which would reveal at each turning a pavilion in green surroundings, and isolated as far as possible. In fact, only from the bridge is it possible to obtain an overall view of this free-style siting in a most picturesque site.

An important part of the Belgian Section is the large Esplanade running from the Auditorium—Hall IX—to an entrance level with the Chaussée de Meysse, with a large car park just at the side. This esplanade, where the big opening ceremony took place, is decorated with flowered tiers and a royal stand has been erected along the rear façade of Hall IX. On its west side, the Esplanade is bordered by the halls of the " Air, Sea and Land Transport Associated Exhibitors," and on its east by a set of porticos through which the view falls upon the " Flemish Garden," with the extensive woodland of Osseghem Park behind.

The backbone of the Belgian Section is the former Avenue du Centenaire which has been renamed the Avenue de Belgique. This avenue, along which the halls of the " Associated Exhibitors " hold the visitors' attention by their grandeur and soberness, has been subjected to severe constructional planning ; first by imposing outlines which the architects responsible for the construction of the various halls have had to respect ; secondly, by keeping to an extremely rhythmical architecture in order to maintain the impression of unity which has been the aim ; lastly, by carefully alternating green spaces and buildings. Still with the idea of avoiding any resemblance to the 1935 Exhibition, when the Avenue du Centenaire was, one might say, the principal clearing before the Main Halls, to a certain extent the perspective created by this Avenue has been broken. Where the Avenue du Centenaire and the Avenue de Bouchout intersect, the Atomium has been sited. At the point where the Avenue du Centenaire opens on to the Esplanade of the Main Halls, an enormous portico has been erected which also serves to avoid any " overwhelming " effect which the Atomium might give visitors coming out of the reception hall.

The appearance of this main thoroughfare of the Belgian Section is greatly enhanced by an abundance of flowers and plants. In addition, on both sides of the Avenue, there is a " water stairway " which replaces the former fountains in the Avenue du Centenaire and extends from the Place de Belgique to the Benelux Gate. With a total length of 4860ft, it consists of a series of steps 35ft wide over which water flows down through fifty-three basins. Between adjoining basins are two 11in high waterfalls. The basins are illuminated in blue and the waterfalls in yellow colour. The Avenue itself is lit by pylons but indirectly by the light from the halls all along it ; windows are placed in the lower part of the façades of the halls and when the halls are closed, these brilliantly lit windows display the objects exhibited in the various pavilions.

Lighting and fountain displays are useful, even essential, adjuncts in bringing to life the presentation of architectural ideas. In these matters, the organisers of the Brussels Exhibition have visualised things on a large scale, both from the practical and the æsthetic point of view, and have sought the co-operation of leading hydraulic and illuminating engineers.

Some idea of the scale of the illuminations is conveyed by the fact that the electric power installed amounts to some 56,000kVA, with an estimated consumption of about 20,000,000kW. For the two available high and low tension voltages—110V and 220V—the electrical supply to the five networks required 75 miles of cables, 12 miles of which were for the automatic safety circuit.

The ornamental water displays have required the installation of many miles of water pipes and pumps with an output of millions of gallons of water per minute.

Throughout, the Belgian Section is lit by fittings placed at the top of tall masts of prestressed concrete. Each mast carries sixteen corrected-colour mercury vapour lamps of 1kW each on a frame the shape of a four-leafed clover.

The Flemish Renaissance Garden is illuminated with flood-lights placed in the corners of the four sections so that flowers and fountains stand out in brilliant relief.

Apart from these special areas of lighting, discreetly concealed spotlights are placed under the pergolas, and each building will be illuminated.

On the " Place de Belgique " the lighting is of a different kind. The arch over the enormous new façade has been given a double row of white, cold cathode lamps, while the façade itself is covered with over 100 stars outlined in light. This galaxy gravitates round a central motif—a dove and an enormous star which stand out in black against the background of white light. Similarly, the columns of the peristyle, with lights concealed in small cavities, stand out in silhouette. The square is surrounded with twenty-three arches, each 32ft high, and bearing the arms of a Belgian town outlined by fluorescent tube lighting.

The Centenary Palaces Gate, measuring approximately 130ft by 160ft, presents a contrast of deep shadow and bright light by means of powerful oblique light rays which consume up to 60,000W.

In front of the gate, the patio itself is softly lit by eight flood-lights placed in the fountain basins. A mast 112ft high is the source of illumination for the pond, the entrance itself and the nearby bus station.

Hall XI

The Centenaire Grand Halls, erected for the 1935 Exhibition, consisted of five halls with an overall area of 500,000 square feet, arranged around a court of honour.

Once this great international event was over, these buildings were used to house the now traditional annual fairs and shows. Later it became necessary to connect the three main buildings by means of a " Hall," which was to be erected at the rear of the group. This building was finished in 1937, and further enlarged in 1948–49, as far as the extreme limits of the site, which belongs to the City of Brussels.

Beyond were military installations, the Roman Highway and the slightly undulating fields towards Meisse, Wemmel and Strombeek. The scope of the World Exhibition of 1958 called for new buildings, which afterwards will be put at the disposal of the Centenaire District, where they will be used to house the important events, the number of which is ever increasing.

On this area two new halls have been built, Hall VII—constructed in 1956—of 120,000 square feet, and Hall XI, measuring 237,000 square feet. No. XI adjoins, to the north, the previously existing five parallel halls, the entire Centenaire group now covering a total area of approximately 1,100,000 square feet.

The front of Hall XI is about 1500ft long and faces the Chaussée Romaine. The problem with which the architects, Mr. R. Puttemans, Mr. Ch. Malcause and Mr. P. Laenen were faced was to construct a building of huge dimensions in such a way that neither the utilitarian purpose nor the monumental aspect should over-ride each other. The plan drawn up provided for a building 500 yards long and 45 yards wide, without any intermediate supports. It is divided into two wings by a vast central portal 192ft wide, which forms one of the main entrances to the Exhibition and leads to the Great Hall.

At both ends of the new Hall, restaurants, brasseries and bars have been set up, while rooms have also been provided for auxiliary services, offices, cloakrooms, Red Cross posts, &c. The construction is based on a metal framework made up of a series of successive portal frames and was the responsibility of the consulting engineers, Monsieur Verdeyen and Monsieur Moenaert. The façades are in aluminium and thus give a rational use of materials, coupled with a harmonious appearance. Full use is made of prefabrication techniques.

The inner walls are of great simplicity, as they must serve as background for the wide range of exhibits ; they were chosen for the ease with which they could be erected and their heat insulating qualities, the more traditional materials, such as stone, marble and bronze, being reserved for those portions whose constructive or decorative aspect commands their use. The architectural effect of this hall is one of great soberness of line, its overall appearance depending on proportions and colour.

Hall VII

For the second new construction, Hall VII, covering an area of 10,750 square metres (12,860 square yards), the same system was adopted as for Hall XI.

Hall VII is situated at the eastern end of the Centenaire group beside the Avenue Masaryck, and takes the place of three halls, 6b, 7 and 8, built for the 1935 Exhibition, which were demolished to make way for it. Its main façade faces the Esplanade. It is composed principally of a vast hall with a reception vestibule in front and with a covered porch leading to Hall VI.

On the first floor and situated above the reception vestibule is a great gallery of 1175 square metres (1405 square yards) which receives its light through an enormous plate glass window looking on to the Esplanade. This window forms the main element of the principal façade. It is held in position by a metal framework made of aluminium and steel. A framework of six welded box-section portal frames covers the hall. Each has a span of 70m (230ft) and is 15m (50ft) high, thus forming bays of 24m (79ft).

As in Hall XI, anodised aluminium was utilised for the frames of the glazed parts of the building, such as doors. The floor of Hall VII is hard rolled earth, except at the entrances, lobbies and galleries, which are either paved with ceramic tiles, cement, or covered with carpets as in the cinema hall and gallery.

The Reception Hall

Hall V has been equipped as a reception hall, entrance to which is by the Patio of Hall XI. The Reception Hall is the reception centre for a very large number of visitors, in particular those disembarking at the Heliport or from coaches, buses and private cars parked in the North Car Park. On the ground floor of Hall V are the left-luggage office, Logexpo offices and the Information Service, where visitors are welcomed and assisted in search of accommodation. Transport documents for all destinations are issued by the Belgian National Railways and foreign

The Brussels Universal Exhibition

Just as the Eiffel Tower symbolised the 1889 Paris World Exhibition, so does the 360ft high "Atomium" (right) symbolise the 1958 Brussels Universal Exhibition, which opened on April 17 and will, it is thought, be seen by some 30,000,000 to 35,000,000 visitors before it closes on October 19. Towering above all other buildings in the Exhibition, the "Atomium" represents the atomic structure of a crystal of iron magnified 150,000 million times. The nine atoms of this crystal are represented by steel spheres, each 59ft in diameter. At night they are lit up by revolving points of light, to give the effect of electrons rotating around the nucleus of the atom.

Exhibitions showing the peaceful uses of atomic energy will be held in the lower spheres, and a high-speed lift in the structure's central column will take visitors to a restaurant in the topmost sphere, thirty storeys above ground level. Numerous "portholes" will afford visitors a spectacular view of the Exhibition and the City of Brussels.

Fifty nations, eight international organisations and institutions of the five Continents are exhibiting under the theme "A Balance Sheet for a More Human World."

The Exhibition covers 500 acres of the Heysel Park, about 5 miles from the centre of Brussels. A large proportion of the whole area, over 130 acres, is taken up by the Belgian section. "New Techniques in the Service of Man" is the common theme of exhibits comprising all aspects of industry, enterprise and research. The Belgian exhibits are of a collective character, i.e. exhibitors carrying on similar activities are grouped into "collectivities."

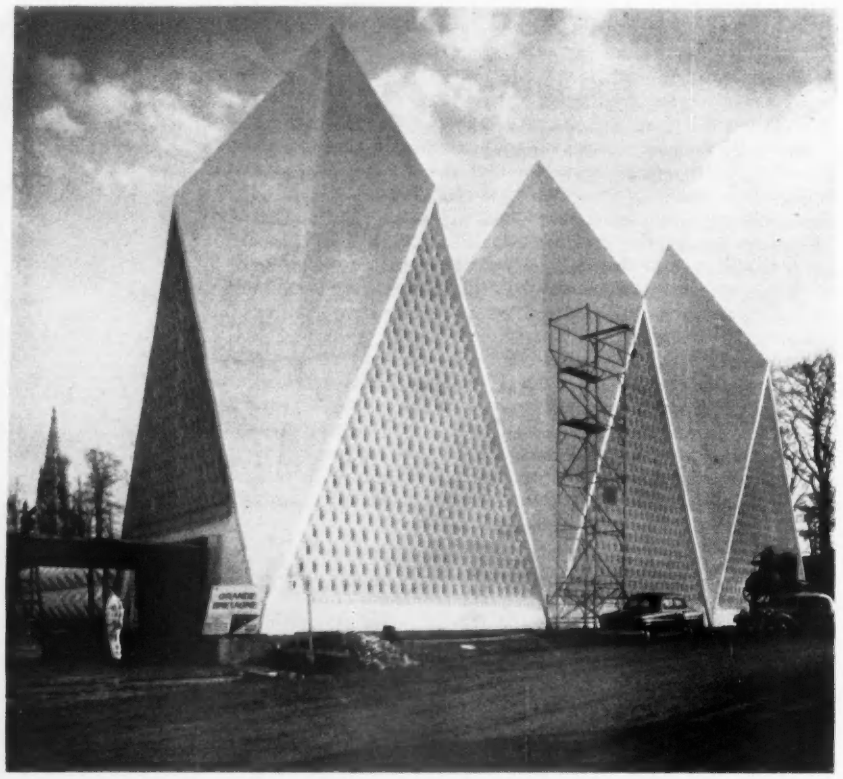
Africa is sometimes called "The Continent of To-Morrow." The native arts and crafts of a gifted, dynamic people are displayed in the seven pavilions making up the Belgian Congo and Ruanda-Urundi Section, which are concerned with Government services; the Catholic Missions; Insurance, Banking and Commerce; Mining; Construction, Power and Transport; Agriculture and Fauna.

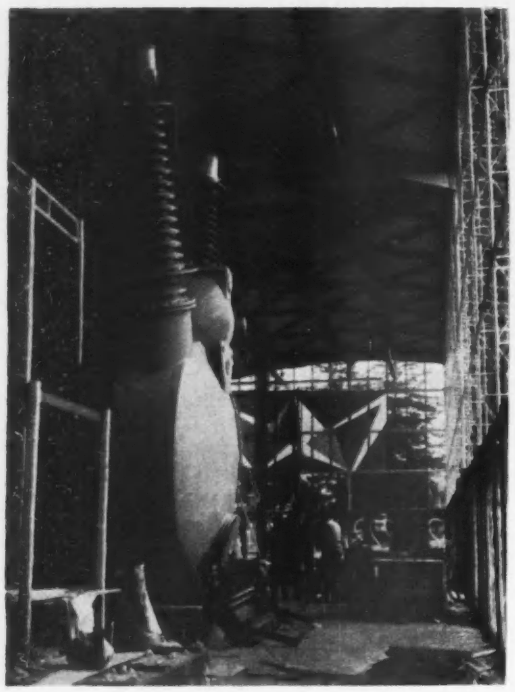
Our illustration above shows a part of the Belgium of bygone days; 12 acres in the heart of the Exhibition feature an authentic reconstruction of Belgium in 1900; 2400 square yards of gardens in bloom, fifty cabarets and five vaudeville theatres and scores of quaint shops beckon the visitors.

On the right we show the great footbridge which connects the slopes of the park of Laeken, starting near the statue of Leopold I in the Avenue des Hetres, to Osseghem park, passing over the foreign sections. It is 490 yards long and about 27 yards wide and spans the Avenue du Gros Tilleul at a height of 46ft. It has been designed so as not to spoil the woodland scenery of this corner of the Exhibition. It has a total of 124 girders of pre-prestressed concrete, each weighing 25 tons. Concessions and services include a Main Reception Hall, with information centre, lounge, rest rooms, restaurants, and shops. A Heliport connects the Exhibition with principal cities of Belgium and adjacent countries. For a rapid survey of an area one-third of that of Brussels itself, a chairlift 2¾ miles long has been installed. In the tradition of the exhibition world, the Amusement Park caters for the adventurous tastes of children of all ages. A completely equipped rocket ship here gives its passengers the impression of a journey to the moon.

The United Kingdom

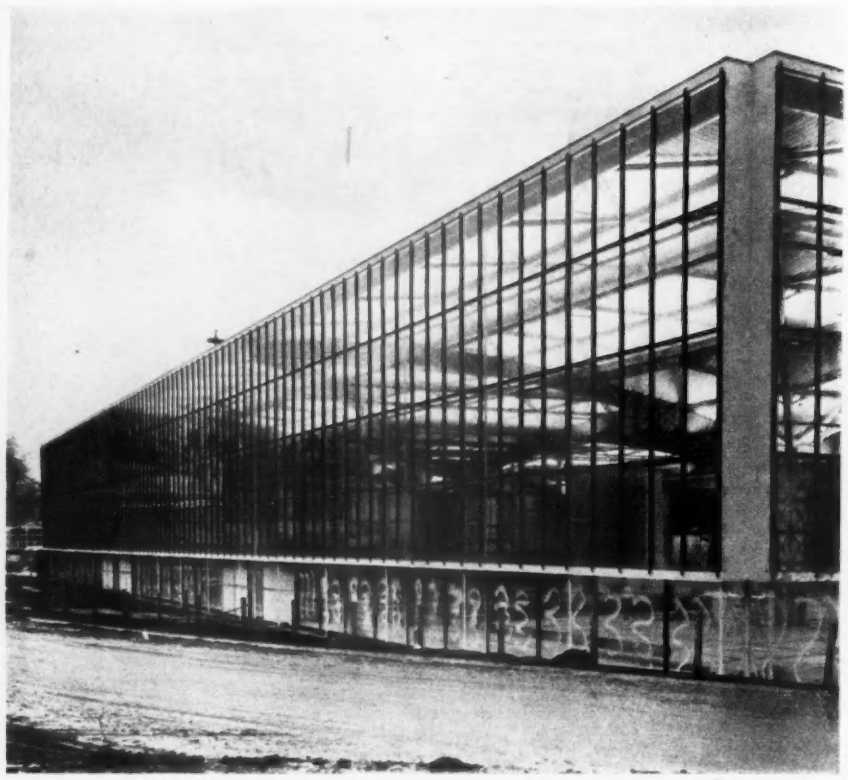
The section of the United Kingdom covers an area of some 5·3 acres, and essentially comprises two buildings: the Government Pavilion, and the British Industries Pavilion. The Government Pavilion, which is shown on the right, is dedicated to the British tradition. Towering above it are three 70ft high crystal-shaped, pointed structures, the sides of which are made of plywood pierced with a multitude of coloured-glass apertures which, by dint of artificial lighting, give a strikingly modern stained glass effect. The wooden supporting structure comprises twenty-four identical panels, the stressing and ribbing of which were derived from aeronautical design. This resulted in extremely thin components which, in fact, are only about 6in thick. Visitors pass under a canopy of illuminated Tudor roses with, at its end, the Royal coat-of-arms in illuminated "Perspex." They see a display of regalia, heraldry and grouped figures representing law, government, the universities and civic authority. This display leads up to a portrait of Her Majesty Queen Elizabeth, an enlargement of the study by Annigoni.





Adjacent to the "Hall of Tradition" is the "Hall of Technology," a low, single-storey "L"-shaped building measuring approximately 200ft by 63ft. Its roof rests on columns rising around its perimeter, and is supported by a space lattice made of prefabricated steel units 4ft by 4ft by 3ft high which were assembled *in situ*. In this way, the centre is kept clear of obstruction. Visitors pass along a gallery flanked by a glass wall in which are embedded translucent designs, representing recent advances in the understanding and control of physical environment. This display includes a series of illuminated maps showing the world-wide influence of British scientific achievement. Among the items shown here are the isolation and analysis of vitamin B12, used for the treatment of pernicious anæmia; the Melrose heart and lung machine, and equipment for radio astronomy, such as the Mullard interferometer set-up at Cambridge, and the Jodrell Bank radio telescope. The climax of the "Hall of Technology" is formed by a 7ft-high model of ZETA. This, to a scale of one-third, represents the original machine at Harwell in which temperatures of 5,000,000 deg. Cent. were first attained on August 30, 1957. The torus of the model is of transparent plastic material so that the interior flash can be seen at ten-second intervals.

The next section is devoted to the British people and what they are like. For this a technique of cinematograph representation is used to show typical British people hard at work and hard at play.

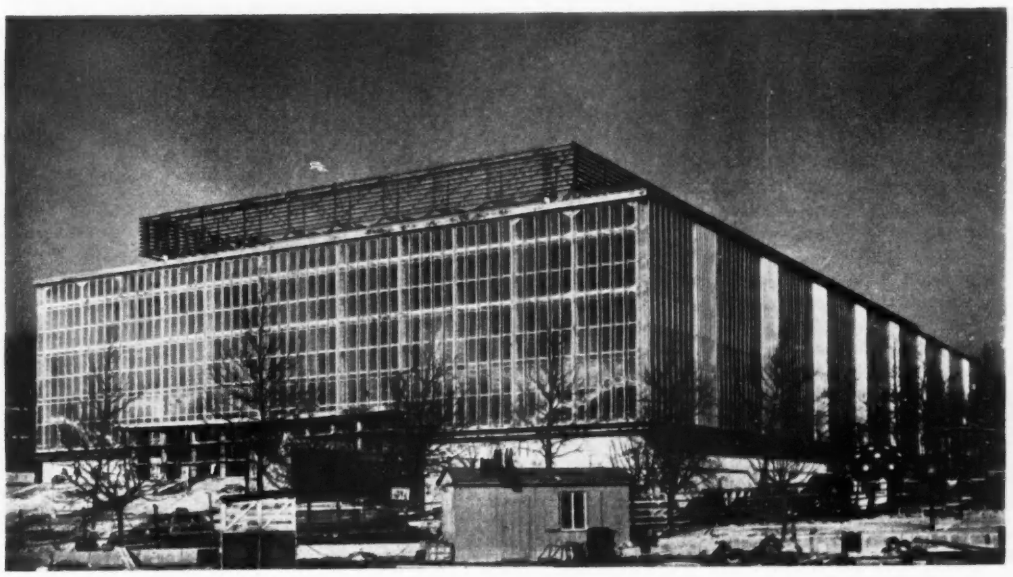


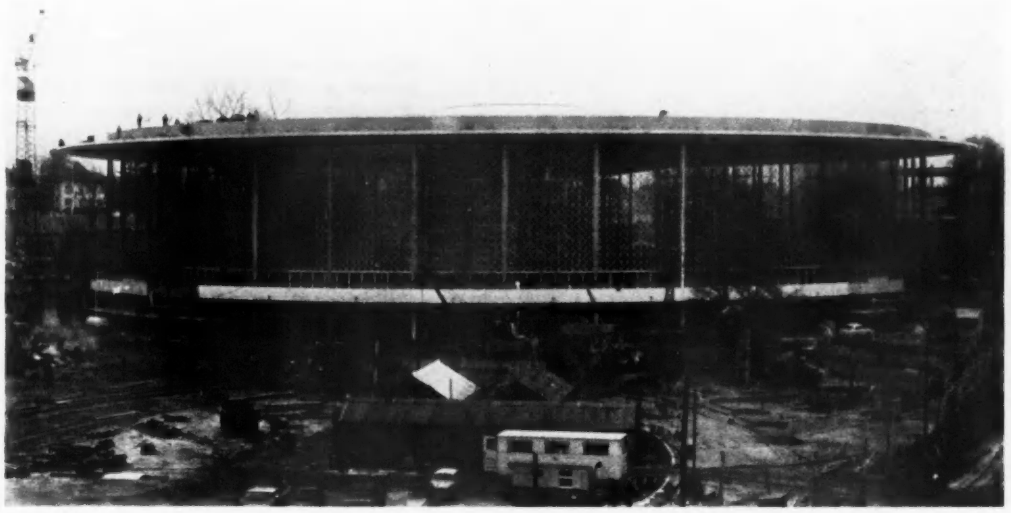
Then follow a number of courtyards dealing with the British as a seafaring people, the British Commonwealth, and everyday life in Britain itself. Finally, there are displayed over 120 exhibits showing some of the many British inventions which have contributed to the well-being of the world over the last 450 years. The other main section consists of the British Industries Pavilion (right), a single-storey hall measuring 300ft by 200ft, and approximately 33ft high. It is enclosed by glass walls and its aluminium roof rests on steel arches supported on six inner pillars. Because these arches are at 45 deg. to the axis of the building, the roof presents a quilt-like appearance from above. Many leading British industries and manufacturers are exhibiting, singly or in groups, a large range of consumer and capital goods, such as the item shown above. They include the British Electrical and Allied Manufacturers' Association, the British Iron and Steel Federation, the Atomic Energy Authority and the Council of Industrial Design.

The 1958 Exhibition will be a vast clearing-house for the exchange of ideas and advancement of knowledge, and the fact that the British Government and industry are jointly playing such an impressive part in the exhibition should enhance the country's reputation abroad. Great Britain is, in fact, the only country which is represented at the exhibition in this dual way.

France, U.S.A. and U.S.S.R.

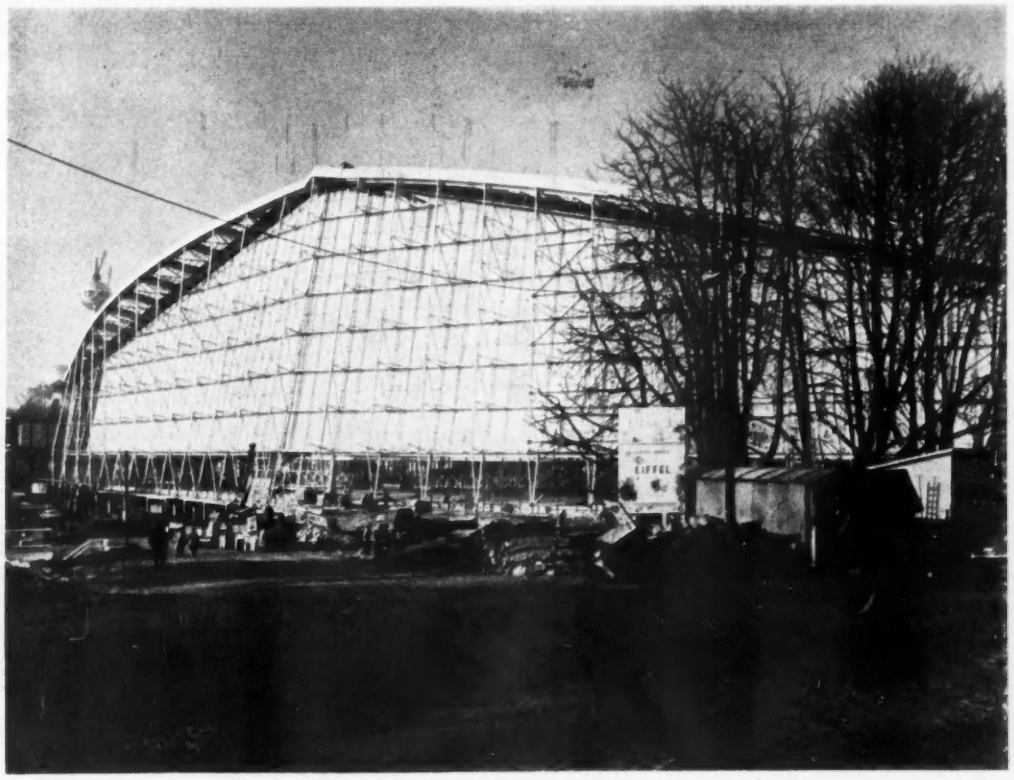
Like France, the U.S.A. and the Netherlands, the U.S.S.R. has been allocated the largest area allowed (29,750 square feet). The large glass-facaded palace (right), result of an all-Union design competition, measures 492ft by 236ft by 65ft high. A wide flight of steps leads to the entrance terrace decorated by a 32ft statue representing labour and technology. Inside, the visitor obtains a general view of the sectional exhibitions, which are arranged on terraces on the sloping ground. Flanked by a 1000-seat cinema, the building, which is constructed from lightweight prefabricated elements, will later be re-erected in Moscow.





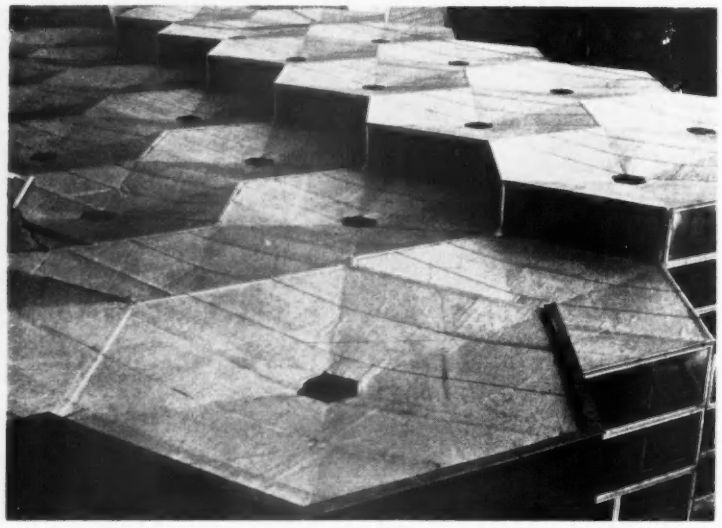
A particularly daring and original building is the main pavilion of the French section (below), designed by Monsieur Guillaume Gillet, who also created the adjoining Paris Pavilion. It derives from the requirement, on account of soil conditions, to limit the weight and the number of supports. In fact, the 12,000 square metre, 2000-ton building—nearly one-quarter the weight of the Eiffel Tower—has only three main supports. Its roof is formed by two similar, skew-symmetrical, rhombus-shaped space frames having one common side. Steel cables for carrying the sheet steel roofing are stretched between the sides of the frame, so as to form two doubly curved (hyperbolic paraboloid) surfaces. The 83m long sides have three low-level corners 15m above the ground, and three high corners, 32m up, so that each side makes a 20 per cent slope with the horizontal. It is only at the lower corners, which are joined by tie girders, that the reactions are transmitted to the ground, with three-quarters of the total force being taken by the lower corner of the side which is common to the two halves of the roof. At that point also a sloping mast is attached as counter-balance. The quasi-vertical light-weight walls are glazed or plastic-covered.

With a diameter of 116m and standing 21m high, the United States pavilion (above) is claimed to be the largest modern circular building, and is approximately equal in size to the Colosseum in Rome. The roof is formed by plastic-covered radial cables attached to both ends of a central vertical drum, and to an outer ring supported on columns. A plastic-covered lattice work forms the walls. Under the annular first floor level, 4m above ground, are offices and ancillary services, including a 4MW power station. A 360 deg. cinema and theatre for 1200, built partially underground, are nearby.

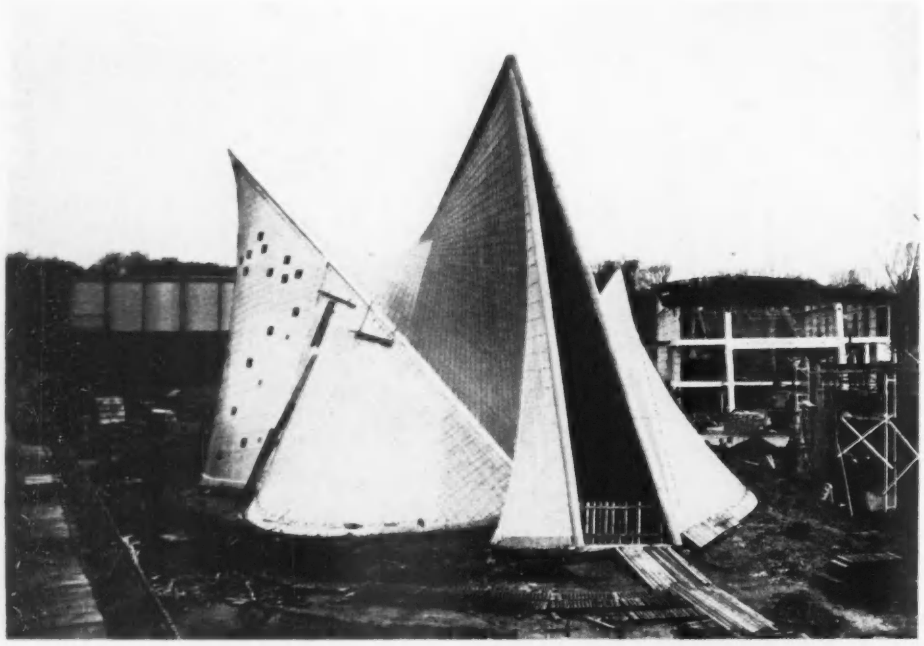


Spain and the Netherlands

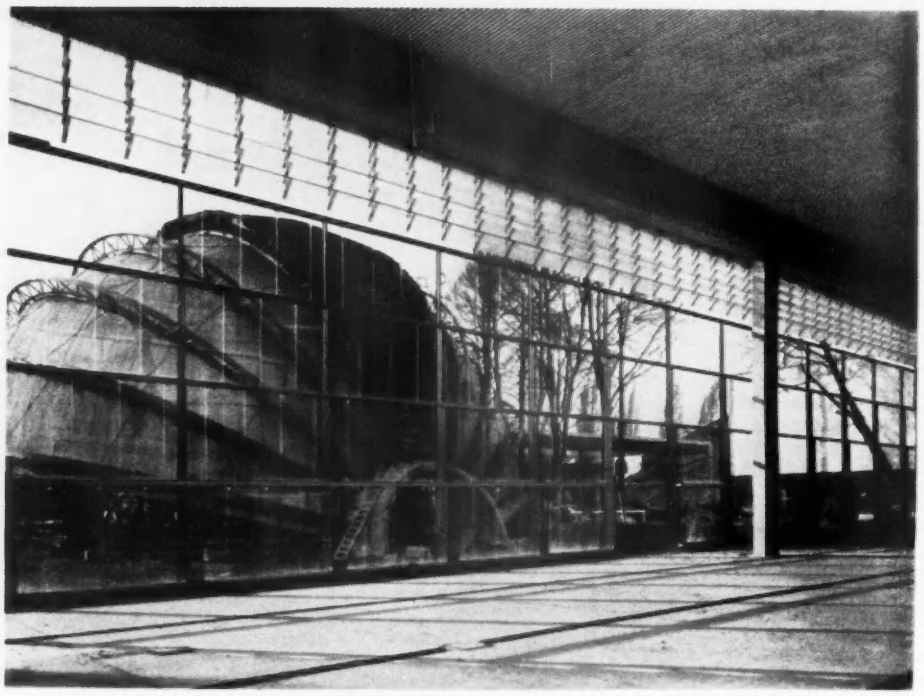
The Spanish Pavilion, situated on a sloping site rising towards the centre, makes use of the ingenious roofing method shown on the right. Over 100 of these hexagonal umbrella units are employed to roof over an elongated area, which includes a cinema and restaurant. The roof units are drained through the hollow central supports. By varying the height of the stem some variety of the architectural rhythm has been introduced.



Below is shown the pavilion of the Philips Concern; it is the design of Le Corbusier, who also wrote the scenario for the "Light and Sound" spectacles which are performed there, and for which Edgar Varèse contributed the sound effects. It is anticipated that one-tenth of the total number of visitors (35,000,000) will visit the pavilion. Since the auditorium seats 500 people, this means that forty performances have to be given daily, each lasting ten minutes. The apparatus for these performances is fully automatic. The structure is built up from 2000 concrete slabs of different shapes and dimensions, on a scaffolding which required 120 cubic metres of timber. The slabs were poured away from the site on sandhills which were of the same shape as the finished wall. They were held in position by a system of ¼in diameter stressed wires, which were subsequently embedded in concrete. A 1 : 25 model of the building and full-size components were subjected to prolonged tests at the Institute for Buildings Material Research at Delft and at Delft Technical University.



The Netherlands, exhibiting on an area of 25,000 square metres, have based their participation on the theme "Water—Friend and Foe." In the dome-shaped pavilion shown below are presented small-scale models, graphs and other objects describing the reclamation of the Zuider Zee and the proposed measures constituting the Delta Plan. The exhibition, which is on sloping ground, is divided into two main portions. The lower part depicts the polder landscape and shows the Netherlands as an agrarian country, while the upper level gives an impression of the industrial development. These two sectors are separated from each other by a dyke. Water from the low-lying canals is pumped over the dyke into a basin, which, in turn, serves the industrial sector for demonstrations of shipping, coastal lighting and other marine activities. Pavilions flanking the upper-level water basin on two sides house the collective contributions of various industries, including trade and transport. Here, too, is shown a cross section of the country's cultural and spiritual life and its social development.



railway companies at a booking office with ten windows.

The leading airlines, travel agencies and tourist organisations have offices in this hall, where there may also be found two conference halls, a restaurant seating 250, branches of banks, a post office with fourteen outside telephone call-boxes and, in its neighbourhood, fourteen public call booths (twenty-four further telephone booths being at various points on the ground floor and twelve on upper floors); Telex-Belino cubicles; a cafeteria accommodating 240 persons; a "hotel de jour" in which travellers tired by a long journey can snatch a few hours of rest. An area of approximately 1900 square yards is occupied by 100 cubicles with either bath or shower. A supply of toilet articles will be available to the public.

Among the many other services offered by the Reception Hall are a shoe repair shop, a laundry, a quick-cleaning depot, an invisible-mending workshop and a stationery store, shops selling souvenirs, ladies' and gentlemen's underwear, toilet articles, tobacco and newspapers—everything, in fact, that the visitor is likely to need. There are also two hairdressing saloons, one for ladies and one for gentlemen.

The Atomium

An outstandingly original structure is the "Atomium" which is to the 1958 Exhibition what the Eiffel Tower was to that of Paris in 1889. The design represents the model of an elementary crystal of iron to the scale of 150,000 million. Being "body-centred cubic," it comprises nine atoms, represented by spheres, at the corners and centre of a cube. For structural reasons, this cube is placed with one diagonal in a vertical direction. The Atomium is about 110m (360ft) high and its nine spheres are 18m (59ft) in diameter.

Weighing 1200 tons, it is constructed of high tensile steel, the spheres being covered with electrolytically polished light alloy sheet. The distance between the spheres, measured along the edge of the cube, is 29m (95ft). The three lower spheres, apart from the base sphere, are supported by three pylons built of high tensile steel, which house the descending staircases. These pylons, as well as the centre base, rest on concrete piles. The nine spheres and the passages connecting them are accessible to the public. A scientific exhibition is located in the five lower spheres, and from the top half of the Atomium visitors have an excellent view of the surrounding country. There is a restaurant in the topmost sphere, at a height of approximately 100m (330ft). In the central pylon, a high-speed lift brings visitors from the ground to the top sphere in less than twenty-five seconds. In place of stairways as a means of ascent, the lower spheres have been equipped with escalators, thus making visits easy and agreeable.

A circular pavilion covering an area of 700 square yards and located under the base sphere, is also used for the scientific exhibition. Visitors are able to examine models of reactors, and in particular those destined for the Nuclear Energy Centre at Mol. They are also shown the principal uses to which nuclear energy has been put in Belgium. Charts of Belgium's future power needs are displayed and show how, with the aid of this new source of energy, the country is preparing to meet these needs. Ore and products from the uranium mine at Shinkolobwe (Katanga) are also on view and the process of milling ore at the Olen (Campine) plant is demonstrated in general terms. Finished products (uranium bars, wire and plates) and various manufactures in the field of electronics complete the group's exhibit. In all there are nine floors, each of about 240 square metres (287 square yards), giving a total area of 2760 square metres (3284 square yards).

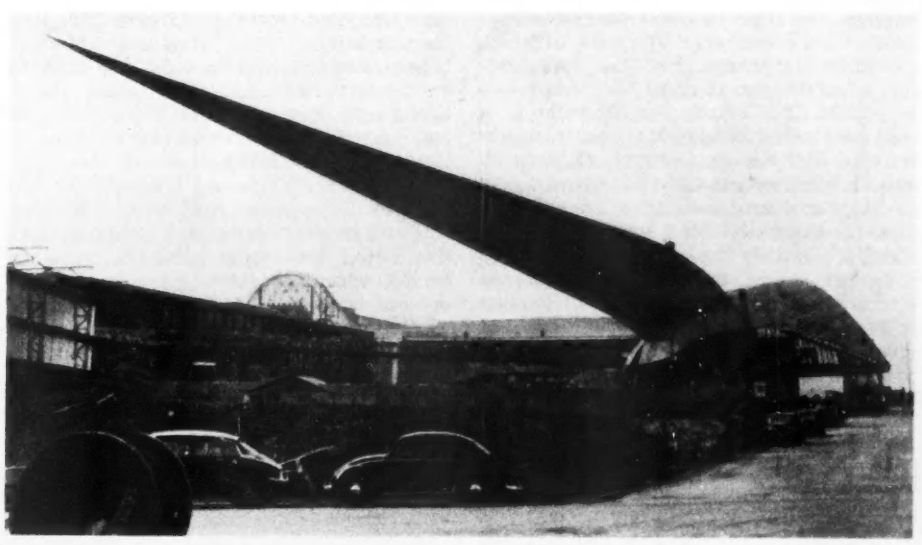
The construction is soundproof, insulated against heat and cold and air conditioned. While the overall height is about 110m, the lower spheres are 40m (129ft) high. The foundations have been built to withstand an overload of 2600 tons.

Exterior lighting consists of points of light placed along nine large circular bands fixed symmetrically around each of the nine spheres. These can be lit successively, giving the impression of nine luminous points revolving rapidly around each of the spheres, and serve to illustrate orbits of electrons turning around the core of the atom.

The design is the work of Monsieur A. Waterkeyn, a civil engineer and a director of Société Fabrimetal. The construction is being undertaken by the Atomium Company (A.S.B.L.), formed by Fabrimetal, the association of Belgian Blast Furnaces and Steel Manufacturers, and the Non-Ferrous Metals Union. Monsieur A. Polak is the architect, Monsieur Beckers and Monsieur Joukoff acting as consulting engineers.

The Civil Engineering "Arrow"

Another structure of unusual appearance and great technical interest is the "Arrow" (flèche) of the Civil Engineering Section. This is a prestressed structure of shell concrete in the form of an 80m long inclined pointed spar which is counterbalanced by an attached domed pavilion built in the same material, the whole structure resting on three supports. From the spar a 60m long footbridge, 2·5m wide, is suspended at a height of 5m above ground level. Underneath, a large-scale map of Belgium has been laid out which shows the principal civil engineering structures.



The "Arrow" of the Belgian Civil Engineering Section under construction. It consists of an 80m long beam of shell concrete, counterbalanced by a dome-shaped pavilion. From the beam a footbridge is suspended over a large relief map of Belgium

The most striking part of the structure is perhaps the main spar with its pointed arrowlike shape. It has been designed as a beam of constant maximum stress, i.e. the section varies in such a way that the maximum working stress is reached simultaneously over the whole of the length. The cross section of the arrow has the shape of an inverted letter "A," the two slanting strokes of which represent two thin concrete shells varying in thickness from 12cm at the root to 4cm near the tip. A number of transverse ribs and two upper longitudinal flanges act as stiffeners and casings for the reinforcing elements. At the root, these reinforcements consist of fifty-four rods of 1¼in diameter rods in each upper rib and thirty similar rods in each side of the intermediate horizontal plate.

The spar has to withstand stresses arising from its own weight, those transferred by the suspension bridge, and wind loads. Accepted stress figures are stated to be: concrete, 100 kg per square centimetre; mild steel, 1400 kg per square centimetre; cressellated steel, 2100 kg per square centimetre.

The slanting arrow grows out of a central pillar which rests on the foundations. This pillar is of variable section. At ground level it has the shape of a triangle, 3·13m long and 1·50m high. All the reinforcing rods encased in the mainstay are pre-bent at their point of entry at the top of the pillar, through which they extend in an almost vertical direction. The maximum load on the pillar is about 1200 tons.

On the side opposite to the spar is a suspended hall which is situated at a height of 5m. It is of triangular shape, each side being some 28m long. The floor is made of a single 12cm thick reinforced concrete slab supported by six radial beams, the total height of which varies from about 85cm to 200cm. Each beam has near its middle a Freyssinet hinge which divides it into two parts, one of which is encased at its end in the central pillar, the other resting on the draw-strut of a bow-string girder.

The roof of this suspended hall is a reinforced concrete cupola of 6cm minimum thickness. Its inner surface follows the shape traced by a parabolic generatrix set in a vertical plane following a directing curve that is approximately a cubic parabola. The rearmost edge of the cupola forms the upper part of the bow-string girder mentioned above. This is a slightly slanting Langer beam. The suspension units are aluminium rods. In view of the fact that some of them are up to 40ft (12m) long, they are reinforced with flat mild steel plates, in order to enable them to withstand wind-generated bending moments. The struts of the bow-string spar abut on the two external angles of the hall, all reactions being transmitted to the central pillar by two precompressed concrete tie-beams drawing elements 37cm by 37cm in

section reinforced with ninety-six rods of 7mm diameter.

Transverse stability of the whole structure is maintained by two lateral struts or crutches which, together with the central pillar, form a tripod. These crutches are, in effect, extensions towards the ground of the cupola itself. They increase in thickness as they slope downwards, being 6cm at the top and 100cm at the base. At the latter point, the sectional area is some 13 square metres. In the most adverse conditions, i.e. maximum load, worst distribution of such load and maximum wind momentum, the greatest possible reaction on each crutch has been computed at 725 tons.

The foundations are formed by "Franki" piles. Under the central pillar there are eighteen such piles, i.e. four vertical and fourteen inclined ones, and under each crutch there are seven inclined piles. The three pile caps are linked by ties in reinforced concrete which distribute part of the horizontal reactions transmitted by the upper structure. The footbridge suspended from the main spar is at a height of approximately 5m above the "Map of Belgium." The usable width is some 2·5m and the permissible load is approximately 500 kg per square metre. Total developed length is 58·6m. The footpath is made of 3in thick reinforced concrete paving flags supported on lattice girders which also serve as guard-rails. The girders are of variable span, the longest spanning 9·8m. Spacer members take the form of struts suspended from the reinforced concrete main spar. As a result, there is no intermediate strut to spoil the downward view. The sixteen units by means of which the footbridge hangs from the main spar vary in length from some 10·67m to approximately 23·65m. Each unit is made of a mild steel tube of 1in (25mm) outer diameter and $\frac{1}{8}$in wall thickness (3mm). Each such tube is precompressed to approximately 20·1 kg per square millimetre by means of three hardened steel wires 7mm in diameter, which are initially stressed to approximately 36 kg per square millimetre and fastened within the tube. Under maximum loading on the bridge, the tension is some 5·8 kg per square millimetre on the tube and 61·9kg per square millimetre on the wires.

Britain at Brussels

The main British contribution to the Exhibition consists of two pavilions on a 5 acre site, a Government Pavilion and a British Industry Pavilion. These two pavilions thus occupy one of the largest sites in the Exhibition.

On Plate 2 in this issue we briefly describe the British Section as it appears to visitors who enter the Hall of Tradition and make their way through the Government Pavilion to the Pavilion of Industries. It is the object of this first section to give those coming to the World Exhibition—and estimates vary between 30,000,000 and 50,000,000 people—an impression of the British way of life, its traditions, institutions, and achievements in scientific and cultural respects, as well as a picture of everyday affairs in this country. The second aspect of the British contribution, Britain as a factor in world economics, is presented by the industrial effort displayed in the British Industries Pavilion.

Hall of Tradition.—Three great crystal-shaped spires, 70ft high, form the entrance building, which towers above the rest of the pavilion buildings and is seen against a background of beech trees. This Hall of Tradition is as long as a large parish church. The triangular side walls are pierced by hundreds of small apertures set with coloured glass which at night are illuminated by thousands of miniature coloured lights.

Visitors entering the hall pass under a canopy of illuminated Tudor roses with, at its end, the Royal Coat-of-Arms in illuminated "Perspex." The interior of the Hall of Tradition is designed to create a dramatic atmosphere. Here can be seen a display of regalia, heraldry, and symbols representing the continuity of tradition with contemporary Britain. On a stage are grouped figures representing Law, Government, the Universities and Civic Authority. This display leads up to a portrait of Queen Elizabeth, an enlargement of the famous Annigoni study of Her Majesty.

On leaving the Hall of Tradition, the atmosphere suddenly changes. The visitor is confronted with a view of the site of the Dounreay atomic reactor on the coast of Scotland.

Hall of Technology.—This hall, which follows, is, in contrast to the high entrance chamber, low and wide. Visitors now pass along a gallery, flanked by a glass wall in which are embedded translucent designs, and including a series of animated and illuminated maps showing the world-wide influence of British scientific achievement.

Among the latest advancements of British research portrayed in the Science and Technology Section are the isolation and analysis of Vitamin B12, discovered at the Glaxo Laboratories in 1948 and since developed by X-ray crystallographers and chemists as a cure for the formerly incurable disease of pernicious anæmia. The Melrose heart and lung machine, recently developed at the Hammersmith Post Graduate Medical School, London, with the aid of the Nuffield Foundation, enables surgeons to gain direct access to the interior of the heart for operations and is now being produced by New Electronic Products, Ltd. Illustrations are given of the use of radioastronomy for probing outer space by means of new equipment such as the Mullard interferometer at Cambridge, and the Jodrell Bank radio telescope. Another exhibit concerns the revelation of the chemical basis of heredity by the use of nucleic acid, which provides sound basis for the hypothesis that genetic information is "coded" in an astronomical number of permutations. The effective technique of deep ploughing, which has greatly increased the extent and quality of the new forests being planted in Britain, is illustrated by another display showing the advantages of this method. Also concerned with the land are sections devoted to the improvement of crop yields and the cultivation of previously unusable soils by a method arising from the discovery and isolation of "trace elements" at the University of Bristol, and the value of rootstocks in the propagation of fruit trees by processes developed at the East Malling Research Station.

The visitor is then able to inspect a model of "ZETA," 7ft high, by means of which a representation of the Harwell experiments towards controlling fusion is given. "ZETA" (zero energy thermonuclear assembly) is the Harwell machine in which temperatures hundreds of times higher than those on the surface of the sun were attained in experiments which have led British scientists to the conclusion that the control of fusion and the use of the waters of the oceans as fuel for power may well be a possibility for the future.

The Brussels model is to a one-third scale of the original. Its torus is made of "Perspex," so that the interior flash can be seen at ten-second intervals. Mounted on a platform, it is so sited that it forms a natural climax to the series of scientific exhibits. Flanking it is a display of thirty-five British Nobel prize-winners in the field of science. An adjacent supplementary display shows an illuminated image of the sun. There is also an inscription which states that "On the night of August 30, 1957, a great step towards a new source of power for mankind was taken. On that date scientists at Harwell succeeded in attaining temperatures of five million degrees centigrade and released neutrons in the thermonuclear reactor known as ZETA."

The British People.—The next section is devoted to the people of Britain and what they are like. For this a new technique in cinematograph presentation has been developed to show typical British people hard at work and hard at play, e.g. in an engineering workshop, eating fish and chips or drinking tea!

In the following gallery, which leads out into the open air, is shown the influence of the British as a seafaring people, how past adventure and discovery have led to the building of nations. In an open courtyard the massed flags of the Commonwealth fly from a forest of stainless steel masts.

The designer and architects have taken advantage of a fine group of trees in the centre of the site to lead the visitor under their shade through a series of walled courtyards. Here the visitor may sit for a while and relax or stroll in and out of a maze of displays and ingenious fountains.

Exhibits under these trees portray something of the character of the British people—their interest in up-to-date schools, gardens, flowers and outdoor pastimes, and also that they do not always take themselves too seriously.

Other exhibits show the contribution which literature, the drama and music make to the British way of life.

Courtyard of Invention.—In the final courtyard are displayed some of the many things and ideas which "started in Britain" and have made their contribution to the well-being of the peoples of the world.

This may be something of a revelation to the visitor, illustrating, as it does, a remarkable series of important contributions to modern civilisation. Everyone knows that Britain gave to the world the condensing steam engine (James Watt), penicillin (Sir Alexander Fleming) and television (John Logie Baird), for example. But many people may not realise that British brains were responsible for coke (John Thornborough), the propelling pencil (Joseph Bramah), cellulose plastic (Alexander Parkes), friction matches (John Walker), the electric clock (Alexander Bain), elastic (Thomas Hancock), bottled beer (Alexander Nowell), linoleum (F. Walton), road cats-eyes (Percy Shaw), stick-on rubber soles and heels (Walter W. Phillips), the folding camp bed (A. E. Anderson), and even the water-closet (Sir John Harington). The series of more than 120 exhibits covers a time span of 450 years. Emerging from the trees, the visitor passes by a bridge over a small lake which is enlivened with boats and fountains.

Immediately ahead is the glass-walled British Industry Pavilion. In front of it is a wide paved area where the visitor may stroll among kiosks and shops or take some refreshment at the "Britannia Inn."

The British Industry Pavilion

The Pavilion which cost over £400,000, occupies 60,000 square feet of covered exhibition space, enclosed by walls of glass and covered by an umbrella-like roof, supported by six central columns. Prominently situated and brilliantly lit from within during darkness,

the building displays by day and night some of the newest of British products.

The largest single area in the British Industry Pavilion is occupied by the British Electrical and Allied Manufacturers Association. There is, for example, one exhibit which emphasises the quality of British steel and shows thematically the processing of the raw material and the various stages leading up to the production of the finished article. Power production is represented by exhibits showing how electricity is generated from coal, water and oil, and by the latest developments in this field chosen by the Atomic Energy Authority and the Nuclear Power Plant Company.

From among the industrial exhibits we have selected the following for more detailed description.

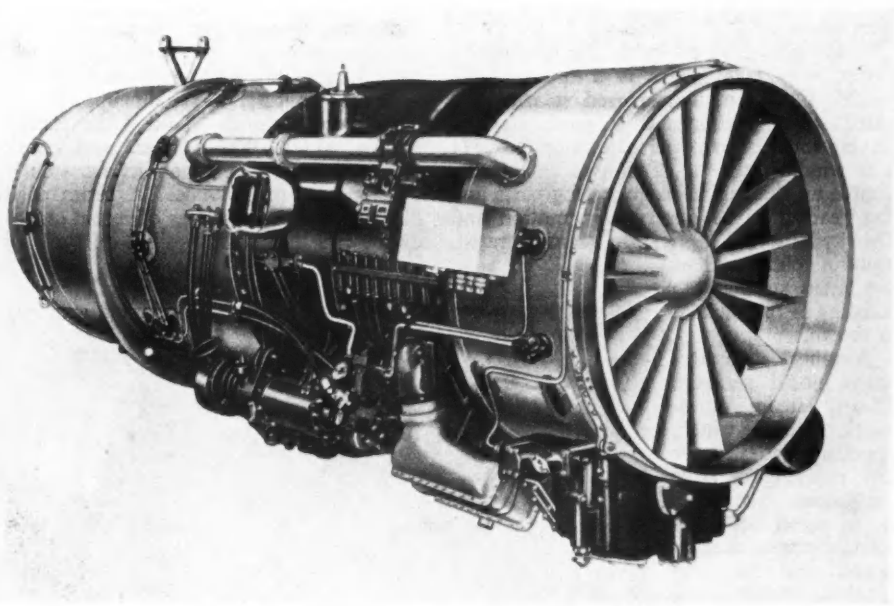
The two-storey stand of the British Iron and Steel Federation is an all-steel structure built up of a system of columns, channels and castellated beams. The upper floor is being used to provide office accommodation and a lounge for visitors. The ground floor and the outer walls of the first floor are used for some sixty exhibits of typical applications of steels, and there are also explanatory panels covering the quality and performance of British steels.

These exhibits include a large colour transparency of a new electrolytic tinning line at Velindre, which is shown as an example of the six new electrolytic tinning lines installed in Great Britain since the war. A large-scale model shows Durgapur steel works, which is being built by a British consortium near Calcutta and will start production next year. Samples are included of a universal beam, 3ft high with flanges of 16½in, which will be produced in the new mill at Lackenby, and an "Alphasil" grain oriented sheet which is to be produced in a new Midlands plant at the rate of 500 tons per week. The aeronautical exhibits include the altitude record-breaking Bristol "Olympus" turbo-jet aero engine and the Napier "Gazelle" 1260/2000 s.h.p. free-turbine engine with a Westland helicopter rotor assembly.

An English Electric fully-bladed rotor disc for a 200MW, 300,000 r.p.m. steam turbine, the largest of its kind in the world, is slowly rotated under spot lighting, and a scale model of the radio telescope in Cheshire is true in every detail of its intricate structure.

An interesting diorama illustrates the new Forth Bridge, which when completed will have a main span of 3300ft and be the longest in Europe. Amongst the other exhibits are samples of integral finned tubes and "Stelvetite" cold reduced sheet steel which is covered on one side with P.V.C. and on the other with zinc.

It was, of course, quite impossible to provide space in the pavilion for all engineering firms, but it is considered that the exhibits give a good impression of the diversity of British engineering products. In addition to a few individual stands of firms, there are collective stands such as that of the Birmingham Exchange and Engineering Centre, where the products of about eighty-five firms are represented. Space restrictions naturally confine the individual firm's exhibits on the stand to small representative units or illustrated panels, but facilities are provided for assisting interested inquirers with catalogues and fuller details of the products of particular manufacturers. It is not possible to give details of all the individual exhibits on this stand, but they include representative examples of machine tools, pumps, valves, compressors, small tools, hydraulic power equipment, conveyors, furnace parts, dust control and ventilating equipment, as well as components such as gears and tube fittings.

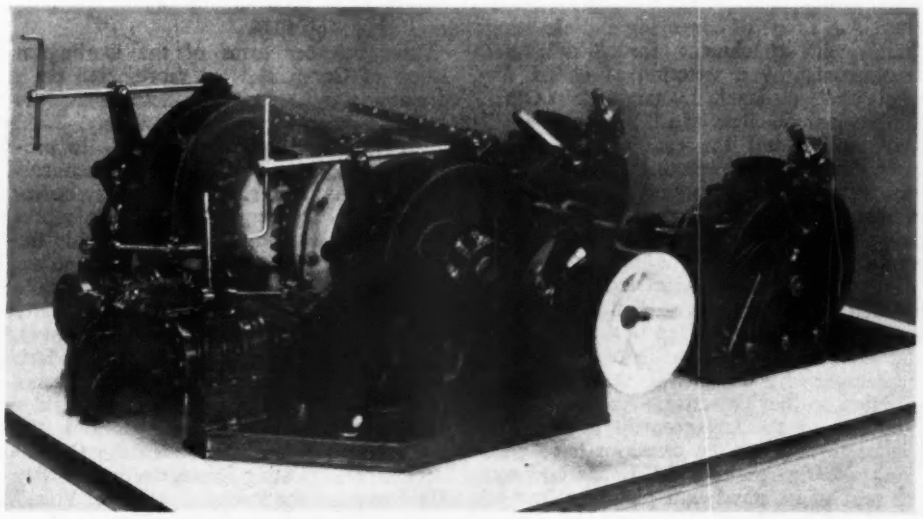


Rolls-Royce "Conway R.Co 10" 16,500 lb thrust jet engine

A representative range of its products, with the exception of the motor-car, is shown on the stand of Rolls-Royce, Ltd. These exhibits include the well-known "Dart," "Avon," "Conway" and "Tyne" aero engines. It is interesting to note that more than 450 "Dart" powered civil aircraft are on order or in service and versions of this engine in powers ranging from 1500 h.p. to 2500 h.p. are in production or under development. Complementary to the "Dart" is the "Tyne" engine, which was introduced to meet requirements for an engine to power aircraft with speeds of 400 m.p.h. or more. It is the first of a type of twin-spool, high compression engines with an effective power-to-weight ratio and economic in fuel consumption. These two turbo-prop engines provide an interesting comparison with the "Avon" medium power 10,500 lb thrust jet engine and the "Conway" with its thrust of 17,250 lb without reheat for military operation, the civil airline version of which, with a thrust of 16,500 lb, is illustrated on this page.

The firm's diesel engines shown cover the range of 60 h.p. to 600 h.p. in four, six or eight-cylinder versions, normally aspirated, supercharged or turbo-charged. The range of 40 h.p. to 240 h.p. petrol engines is also represented on the stand. It is also pointed out that for more than three years Rolls-Royce has been conducting research into the application of nuclear energy to forms of marine propulsion at its laboratory at Derby. In association with Vickers, Ltd., and Foster-Wheeler, Ltd., the firm is engaged on the design and construction of the first British nuclear-powered submarine. The nuclear reactor "Neptune," which is in operation at the United Kingdom Atomic Energy Authority Establishment at Harwell, was designed and built by Rolls-Royce, Ltd.

The stand of Clarke Chapman and Co., Ltd., is devoted almost entirely to the display of marine auxiliaries using working models and photographs. Amongst the eleven main working models there is a quarter-scale model of a self-contained electrically driven worm and spur geared ship's anchor and mooring windlass suitable for a vessel of approximately 8000 gross tons. Roller bowstoppers are fitted forward of the windlass and abutting port and starboard hawsepipes. The quarter-scale model of a 5-ton self-contained, electrically driven worm geared ship's cargo winch has a derrick topping unit driven from one end of the barrel shaft. Its control gear case is illuminated and has a transparent cover so that the action of the various electric contactors



Model of a totally enclosed, splash-lubricated, steam anchor and mooring windlass

can be observed when moving the control handwheel.

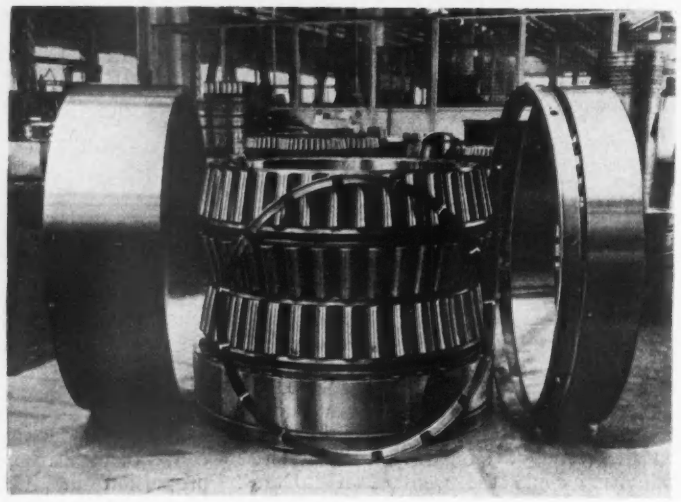
Offering a contrast with the electrically driven equipment there is a quarter-scale model of the totally enclosed splash-lubricated steam anchor and mooring windlass having roller bowstoppers shown on page 571 The windlass covers, of transparent plastic, enable all the engine reciprocating parts and the gearing to be observed in motion and the system of lubrication demonstrated. Endless chain cables are fitted so that the hoisting of the anchors is shown.

Another quarter-scale model shows a 15-ton steam automatic rendering winch, specially designed for the mooring of large oil tankers. The winch is of open construction, having a change-speed gear preset to establish the rendering load in relation to the heaving duty. A wire rope is coiled on the barrel and led through a compensating ring fairlead, and the winch operates on a "heave" and "pay out" cycle to represent the mooring conditions. A coloured diagrammatic drawing illustrating a patent valve system, to provide automatic rendering recovery of mooring ropes, is displayed in association with this model.

The bearings displayed by British Timken, Ltd., range down from a four-row, tapered roller bearing for a rolling mill, which weighs 3½ tons and is illustrated herewith. The largest bearing made by this firm weighs over 4½ tons, and the rolling mill bearing exhibited provides an interesting contrast with a miniature bearing, weighing about 0·001 oz, made by its subsidiary, Fischer Bearings, Ltd. Other exhibits typical of the company's products include railway wagon bearing units, railway axle and cannon boxes, and a sectioned propeller of the "Viscount" airliner cut away to show the specially designed tapered roller bearings supplied for the Rotol propeller blades of this famous aircraft.

Renold Chains, Ltd., shows a selection from its roller transmission chains, standard chain drives, and "A.S.A." roller chain drives. A range of conveying and elevating chains, with attachments for all duties, is accompanied by a selection of chains for specialised mechanical handling. Other exhibits include chain and flexible couplings, chain tools, and the recently introduced sprag clutch. An interesting feature on this stand is a multi-lingual sound system whereby visitors, by pressing the appropriate button, are given a summary of the company's products in any one of five languages.

Imperial Chemical Industries, Ltd., point out that as the organisers of the Exhibition have set out to create "an inventory of the material and spiritual wealth of humanity," the company has designed its stand as a contribution to that objective. As British contributions to the advancement of chemical science throughout the centuries have been many and far-reaching, I.C.I. has laid out one part of its stand as a picture gallery of the numerous chemical pioneers of British stock, from Robert Boyle (1627 to 1691) to Sir Alexander Fleming (1881 to 1955), the discoverer of penicillin. Another section of the stand goes on to show how I.C.I., which has direct historical connections with several of these pioneers, has built upon its rich heritage of research. To-day the company spends £13,000,000 a year and employs 4500 men and women on its research and development programme. A series of displays illustrates a number of recent chemical discoveries of world significance for which I.C.I. research has been responsible, or to which I.C.I. development work has contributed. These discoveries have been made in fields as widely dissimilar as pharmaceuticals and textiles, dyestuffs and metals.



Four-row, tapered roller bearing, weighing 3½ tons, made by British Timken, Ltd., for use on back-up rolls of steel rolling mills. The bearing has an outside diameter of 48in, a bore of 34in, and an assembled height of 35in

In addition to the contributions the firm has made to the industrial and domestic fields by the discovery of polythene—which is marketed under the trade name "Alkathene"—indications are given on the stand of development work on titanium and on metals for use in nuclear power plants, as well as the industrial catalysts made by the company.

At present I.C.I. products number some 12,000 and they range from alkalis, crop protection products, explosives and fertilisers to non-ferrous metals, paints, plastics, pharmaceutical drugs and synthetic fibres. Since the war more than £300 million have been spent on modernisation and new plant construction, and it is of interest to note that on one of two new 1000-acre sites in this country some £100 million will be spent on development by 1975.

Three member firms of the Darlington Group of Companies are represented on a common stand. One of these firms, the Chemical and Insulating Company, Ltd., which processes dolomite limestone to produce a wide range of magnesia chemicals and insulating materials, is showing a selection of its products mounted on a base representing a mass of dolomite. Alongside the chemicals are shown some of the manufactured articles in which they are used, while the insulating materials are linked visually with a display of models illustrating the work of the Darlington Insulation Company, Ltd. The models of four recent insulation contracts carried out by the company include the Calder Hall A and B atomic power stations, the Stella North power station of the Central Electricity Generating Board, the Esso Fawley oil refinery, and the Shell tanker S.T.S. "Vola."

The display of the British Refrasil Company, Ltd., consists of a number of colour transparencies illustrating the use of "Refrasil" as a thermal and electrical insulant in aircraft jet engines, marine and land gas turbines, and a number of other industrial applications.

In addition to the domestic and decorative uses to which its products are put, Formica, Ltd.—a subsidiary of Thomas de la Rue and Co., Ltd.—is showing their uses in transport. Models of railway and motor coaches and a ship's cabin indicate the attractive finish which can be imparted with various colours of "Formica." It is emphasised that the material is hard wearing and the need for redecoration and painting is eliminated. Other exhibits include copper-clad "Formica," which is a laminate, faced with copper foil, now being used extensively in the manufacture of printed circuits, and one side of this display shows the six stages in the production of a printed circuit. Insulating laminates in glass, paper and fabric base, each with examples of the material and their applications, are also displayed.

(*To be continued*)

Plastics Tubing

THERE is now available from Tecalemit, Ltd., Plymouth, Devon, tubing of "Nylon" extruded with sufficient accuracy to be used in conjunction with standard metal pipe fittings. The strength of the material is such that it can afford a weight saving compared to metal piping: an example quoted is 45 lb reduction in weight of the automatic chassis lubrication system of a public service vehicle. The cost is lower than for tubes of non-ferrous metal, and because pre-forming is not necessary, installation costs may be reduced as much as 50 per cent; the polyamide material is not subject to work hardening and cannot require annealing at intervals. In addition to ordinary engineering applications, the plastic piping is suitable for conveying edible materials. Two grades are at present available: semi-rigid, which is pliable and easy to install but intended to endure very little movement once installed, and flexible, which is suitable where large and continuous movement takes place and is a particularly strong pipe in such applications; they are, respectively, opaque black and colourless translucent.

T.T.R. Semi-rigid Tubing.—This tubing will resist degradation when exposed to strong ultra-violet light or oxidation when working at continuous elevated temperatures over long periods. Thus, the tubing can be used, we are assured, on all outdoor applications, in arctic winter and desert summer conditions, and even when in continuous proximity to sources of heat.

The T.T.R. nylon tubing is available in two grades, either high pressure with a short time burst pressure rating of 2500 lb per square inch, or low pressure with a short time burst pressure rating of 1000 lb per square inch. Both grades are precision extruded to limits of +0·000in to −0·003in or −0·005in, according to outside diameter, and are thus suitable for use with standard compression fittings. Special drive-in fittings are also available for each pressure range.

The semi-rigid tubing is available with a range of outside diameters varying between $\frac{1}{4}$in and $\frac{3}{8}$in.

T.T.F. Flexible Tubing.—This flexible tubing, with appropriate end fittings, will readily replace rubber and other conventional flexibles for a very wide range of purposes. The maximum working pressures depend on operating conditions. This tubing is available with outside diameters of $\frac{3}{16}$in and $\frac{5}{16}$in. Other sizes up to $\frac{1}{2}$in can be extruded for reasonable quantities.

T.T.F. flexible tubing can also be supplied in appropriate lengths with specially pre-formed ends which allow connectors to be pressed in by hand.

Institution of Naval Architects

ANNUAL SPRING MEETING

No. III—(*Concluded from page* 539, *April* 11)

THE second paper read on Wednesday afternoon, March 26, was :—

THE HYDROFOIL BOAT: ITS HISTORY AND FUTURE PROSPECTS

By P. R. CREWE, M.A.

SYNOPSIS

The history of hydrofoil boats is traced from the earliest days of their development, and the main systems that have been invented are considered in their original and present-day versions. The advantages of this type of craft, compared with high-speed planing boats, are described. These comprise in particular lower resistance and better and more comfortable behaviour in rough water.

It is argued that serious application of the hydrofoil principle had to await the development of analogous design concepts in the field of aeronautics, and of suitable structural methods and materials. The ground work necessary for the successful design and construction of passenger ferries carrying up to seventy people, was not available until the 1940s, and the aftermath of the war delayed practical achievement until the early 1950s.

The problems of designing boats up to, say, 50 tons displacement, and having cruising speeds of around 40 knots, are now considered to be solved. These craft can operate satisfactorily in comparatively rough seas (e.g. up to 6ft waves, depending on boat size) and also at high speed on inland waterways. It is expected that the present rather limited disposable load (a fuel and payload together of about 25 per cent of all-up weight) will be improved. This improvement will come in part from a decrease in percentage structure weight arising from further developments in the techniques of constructing the hydrofoils.

It is shown that an outstandingly new field of marine craft performance is open to any vessel that can travel at, say, 70 knots, with a lift-to-drag ratio of 15 and a propulsive efficiency of 65 per cent. Special purpose designs using hydrofoils and having speeds of at least 60 knots are possible now, but disposable load is small. Serious consideration of hydrofoil craft designs capable of speeds in the 50 knot to 100 knot range awaits the development of efficient practical supercavitated hydrofoils.

Descriptions are given of the major detailed design considerations that determine the hydrofoil configurations. They are, in particular, cavitation, static and dynamic stability, and structural requirements.

Some model tests made by Saunders-Roe, in connection with the Canadian "Bras d'Or" research hydrofoil boat, are discussed.

DISCUSSION

Mr. H. M. Barkla exhibited a film showing the behaviour of a craft fitted with the "Hydrofin," a system developed by Mr. Christopher Hook. The system employs mechanical sensing devices; two hydroskis are mounted on long jockey arms ahead of the craft, and these are linked, mechanically or hydraulically, to fully submerged main hydrofoils, each of which supports about one-third of the craft all-up weight, in fully foil-borne conditions. The film showed that the craft followed the longer waves, but did not follow the shorter ones.

Mr. H. P. Rader: Comparing the merits of the various hydrofoil considerations, Mr. Crewe concludes that cavitation and structural requirements may favour the use of ladder systems on high-speed designs. In a diagram classifying hydrofoil systems by design speed and behaviour in pitch he has drawn a boundary between craft with monoplane foils and those with ladder foils. Apart from three small craft there is only one sizeable craft with ladder foils on the high-speed side of this line. I presume this is the "Bras d'Or." Two sizeable monoplane hydrofoil craft with speeds well above 50 knots, however, are left out—the 17-ton Tietjens "VS-7" and the 46-ton Schertel-Sachsenberg "VS-10." If the Tietjens boat did in fact achieve 55 knots there is no reason why she should be ignored. The speed of 60 knots quoted for the Schertel-Sachsenberg "VS-10" was the design speed, and, from the results of extensive model tests, it appears that, fitted with suitable propellers, the boat would have been capable of the speed quoted.

Structural requirements may favour the use of ladder systems for high speeds, but this does not apply as far as cavitation requirements are concerned. The increase in resistance due to partial or full cavitation is bound to be higher for ladder foils than for monoplane foils because of the greater number of joints between foils and struts in the ladder arrangement.

Had there been more monoplane hydrofoil boats with horsepower/weight ratios of the same order as for the ladder type boats like the "HD-4" and the "Bras d'Or," they would have achieved speeds of the same order. The problems which have to be solved before boats with super-cavitating hydrofoils capable of speeds between 70 knots and 100 knots become a reality are not easy, but should be within the scope of modern technology.

The ride in a hydrofoil boat is considerably more comfortable than in an orthodox high-speed craft. However, the slamming of orthodox high-speed craft which occurs when these boats travel through waves mainly in head seas can be reduced considerably by proper trim control. We have been able to reduce accelerations due to slamming by as much as 26 per cent by this simple device.

Mr. A. Silverleaf: The author tells us of the peculiar mounting of the two screws of the "Bras d'Or," and I should like to hear what the behaviour of this rather complicated transmission was like.

I find myself puzzled by the argument on page 18 of this paper because it seems to imply that there is an absolute limit of hydrofoil loading which is imposed solely by insistence on complete freedom from cavitation. I agree that partial cavitation can lead to unsteady behaviour, lower lift/drag ratio, and to erosion, but I would not regard complete freedom from cavitation as an inviolable characteristic. We can go a little further along the speed range and allow some cavitation which does not necessarily introduce unsteady behaviour and does not necessarily increase drag.

It is stated that the effective aspect ratio of ladder foils of the kind used on the "Bras d'Or" is low. I would have thought the two end shields would have increased the effective aspect ratio. If that is not so, it is only because they do not extend fore and aft sufficiently, and therefore I ask whether there is not a gain to be made by increasing the fore and aft ends so that you get the aspect ratio considerably higher.

As to the prospects of hydrofoil craft, Mr. Crewe is not so enthusiastic or optimistic as were the Americans four years ago, when they talked about ocean-going ships hydrofoil supported. Looking down the list of types of craft it is unlikely that they justify any serious devotion of national resources to the development of this type of craft. It seems to me it cannot be too strongly emphasised that the problems arising are as difficult as those in connection with transonic aircraft, and similar technical facilities and experience are necessary to ensure success.

Dr. E. C. B. Corlett: The hydrofoil boat attracts by virtue of the high lift/drag ratio obtainable from the foils relative to that obtained with a plane boat, which is in effect a hydrofoil with only a pressure surface in operation. But in a plane boat the area of the plane in contact with the water is also proportional to the square of the speed, the weight of the boat being constant. If a hydrofoil boat depends on incidence change, as in an aircraft, for limiting the required lift, there might be advantages with this kind of fully submerged foil relative to the flying boat.

On the question of cavitation, at very high speeds—of 150 knots or more—it is very difficult to maintain the water in contact with any curved foil surfaces at all. What does Mr. Crewe consider to be the possibilities for very high speed hydrofoil boats with a wedge section.

With propellers on shafts with a very large inclination from the horizontal, if you draw the velocity diagram for the blades, in the horizontal position you will find that the effective angle of incidence is different for the blade going down and the blade coming up, and this means that the torque becomes variable and there is a lift from the propeller. It seems to me that in some boats, where the angle from the horizontal is very considerable indeed, this lift may reach unmanageable proportions and you may get a bad oscillating action.

Mr. E. C. Tupper: I should like to ask the author to comment on the relative merits of the hydrofoil craft and the helicopter. In his comparison of the hydrofoil craft and the planing form he has shown that the former suffers in respect of payload and that its use will depend upon the importance of its other attributes. In many cases, however, it would appear that, if the lower payload is acceptable, then the helicopter has even greater advantages than the hydrofoil craft. Also, the speed of the helicopter is greater and it can often take a more direct route than a surface vehicle.

Mr. W. A. Crago: Mr. Crewe claims for the hydrofoil concept certain potential advantages, such as reduced resistance; greater maximum speed for a given power; a more comfortable ride; and the ability to maintain speed in severe sea conditions. Of course, there are only two real advantages here, namely, the reduced resistance, which results in a greater maximum speed for a given power, and the more comfortable ride, resulting in the ability to maintain speed in a severe sea.

This last corollary implies that the limitation on performance in waves is set, not so much by the structure, but by the human element, which can stand only so much repeated acceleration. Added to these potential advantages there should be a considerable manœuvrability potential and the absence of the wash normally set up by high-speed craft due to wavemaking.

But there are a number of serious disadvantages and Mr. Crewe has laid emphasis on the way in which the foil weights eat into the payload as the craft size is increased. What has perhaps not been brought out quite so much is that it is a relatively difficult technical design problem to produce a hydrofoil craft that is stable and which in actual practice has anywhere near the optimum performance in waves that elementary theory indicates.

The analogy between hydrofoil craft and aircraft can be extended further, and we can say that when anything goes wrong with a hydrofoil craft the consequences are likely to be serious, and possibly disastrous. I have

seen a number of model hydrofoil craft suddenly crack up under heavy sea conditions; and have a vivid memory of being aboard a hydrofoil craft, not the "Bras d'Or," and recording with reliable instrumentation a roll from the vertical of 23 deg. and a roll rate of 45 deg. per second, and at the same time an acceleration near the L.C.G. of $3\frac{1}{2}$ g.

Once the vices of the hydrofoil craft are appreciated, the engineer, knowing something of the possibility of fatigue failure, is inclined to reject the hydrofoil system, which requires elaborate moving parts in the way of flaps or attitude controllers. Here I am in disagreement with Mr. Crewe. It is true that aircraft have flaps, elevators, and so on; but they do not have to contend with flotsam, marine growths and the relatively rough handling to which the foils of an operational hydrofoil craft must inevitably be subjected. Simplicity and robustness have much to commend themselves.

The term "take off" is used in the paper, and, since it is not defined, it may be misleading. No satisfactory hydrofoil craft in my experience, model or full scale, has ever suddenly heaved itself out of the water up on to the foils at any given speed. Rather the process is gradual, and if C.G. rise from rest is plotted against speed, the curve is surprisingly smooth. The hull and foils gradually exchange their functions in providing lift as the speed is increased, and the actual speed at which the hull is 1in clear of the water is not very significant. On the other hand, as the late Dr. Gawn once pointed out, the speed region where the hull is just in the water presents considerable potentialities for porpoising instability with a poor design.

Mr. L. Woollard, M.A., was in the chair when the meeting was continued on the morning of Thursday, March 27, with the reading of Paper No. 6, which was:—

SCALE-EFFECT EXPERIMENTS ON "VICTORY" SHIPS AND MODELS

PART II.—ANALYSIS OF THE WAKE MEASUREMENTS ON A MODEL FAMILY AND THE MODEL BOAT "D. C. ENDERT, JR."

By DR. IR. J. D. VAN MANEN and IR. A. J. W. LAP

SYNOPSIS

The paper discusses the results of wake measurements behind seven "Victory" models on scales varying from 50 to 18 and behind the "Victory" model boat "D. C. Endert, Jr.," on Scale 6. The scale effect in the circumferential inequality of the wake distribution is examined. The mean wake fractions of the models and the frictional wake fractions for a propeller placed behind a flat plate show a close analogy to the skin friction extrapolation diagram when plotted on a Reynolds number base.

DISCUSSION

Mr. R. N. Newton: The value ascribed to the wake at the propeller position is all-important in the design of the propeller and the prediction of performance of the ship for a given condition of displacement and trim. The distribution of velocity over the propeller disc is also valuable when setting up experiments in a water tunnel to study cavitation. As mentioned in the paper, it is sometimes found expedient to design the propeller with pitch varied radially to accord with the radial variation of velocity.

The paper indicates that the scale effect on wake for merchant ship forms is of large magnitude. It would appear that the reduction in total wake fraction from a 12ft long model to the full scale clean ship of 445ft length is of the order of 30 per cent. Passing from a 12ft to a 28ft model the change in the scale effect is about 10 per cent, and it is interesting to note that this is nearly the same order as that measured by Professor van Lammeren in similar experiments covering scale effects on all three hull efficiency elements. This close agreement between the results of two series of experiments, 18 years apart, is a fitting rejoinder to the criticism sometimes levelled at modern testing technique.

The scale effect experiments on "Victory" ships and models, presented in 1955, described propulsion tests whereby thrust deduction was measured. It would be interesting to know whether the thrust identity wake, or effective wake, obtained in those experiments differ from the nominal wake reported in the present paper. I would suggest to the authors also that it might prove interesting to ascertain whether the mean wake fraction obtained as a root mean square value from the readings of the pitot tubes more closely approximates to the wake determined by thrust identity.

Dr. F. H. Todd: This tendency for thrust deduction to increase rapidly with the increase in size of model and ship has been borne out by a different set of experiments; the results of these were given to the eighth International Towing Rank Conference in Madrid by Mr. Hadler. A model of a submarine was towed in the tank, completely submerged, and the resistance measured; and it was propelled in the same way and we got a value for T for the model. The actual submarine was then tested on the measured mile and the thrust measured, and it was towed 200ft down and the resistance measured, and with these two measurements we should get the thrust deduction for the ship. An interesting thing was that although the Reynolds number was quite different from the "Victory" ship, the slope from the model to the ship was the same as for the "Victory" ship, which lends support to this scale effect on thrust deduction.

For the 1/50th scale model the hull efficiency is about 1·395 and for the ship it is 0·945. This has considerable significance in any question of powering. If, instead of the 1/50th scale model, you take the 19ft model, the change in hull efficiency is still from something like 1·24 to 0·94. So that there is still a change of about 25 per cent even from the 19ft model to the ship. I do not wish to draw too many conclusions, but one wonders just what is the significance of these changes, and I am sure we shall all await with anxiety the final results.

Professor E. V. Telfer: In connection with the general results of the wake measurements, I note the curious asymmetry between the two sides of the ship. In the tables we are given the wake to the third decimal place; yet, if you compare one side with the other, there is probably 5 or 6 per cent difference between the spots. Either that implies that the method of measuring is not exact or it is a genuine difference and is due possibly to the disability that different sides of the same model can be differently affected by the turbulence. I wonder if Dr. van Manen has deliberately tried to alter the turbulence on one side of the ship, to see what he gets as the result of that experiment. It is important to know what are the causes of these differences.

It would appear to be very useful to reverse the model and get the results of the wake astern. It is usually thought that the form wake could be got from the astern wake, and it should be fairly independent of the scale of the model. Could Dr. van Manen make some tests on those lines?

With regard the extrapolation diagram for frictional and total wake fractions could Dr. van Manen give the actual results and also the temperature for each of the tests? For the correct set-up of a diagram of this nature, in addition to choosing the scale correctly, it is possible to modify the diagram also for the exact temperature at which the investigation was made.

It has been shown by Dr. Todd what the acceptance of the thrust deduction valuation and this wake valuation means. But is that the end of the story? Personally, I feel that this thrust deduction increase with scale can only be a consequence of the increased heterogeneity of flow. There is obviously a greater hollowness in the total wake distribution as scale increases, and heterogeneity is likely to be a cause of increased thrust deduction. If that is the explanation of what we are finding then we have to consider what is happening with twin screw ships, where, instead of the flow becoming more heterogeneous, it will be less heterogeneous. With the twin screw series we have thrust deductions reducing with increase of scale, and our lessons about the relative efficiencies of single and twin screw ships may have to be re-learned. I think the possibility of such a conflict is very important in the modern design of the large ship.

Mr. J. M. Ferguson: In the authors' diagrams showing total wake fractions spots are given for one of the models with and without rudder, and I am rather surprised by the relatively small differences shown. In quite a number of our recent propeller and model tests at Clydebank we have found very much greater differences as between with rudder and without rudder conditions, the differences being so large that we have had to make a considerable discount for the rudder fitted condition. Could the authors express an opinion on the apparently higher wake with the rudder?

It is a little discouraging to realise that there is such a large drop in hull efficiency. For many years at Clydebank we have built up propulsive efficiency and often find that the build-up gives reasonable agreement with the actual propulsion efficiency obtained. This very large drop in hull efficiency makes us wonder how we shall introduce the very large torque and still regain the efficiency which we know the ship will actually attain.

Mr. D. J. Doust: The results confirm the rather marked wake scale effects which occur in the range of model sizes between 9ft and 24ft B.P. lengths, and also show how the wake fractions for the "Victory" series are related to those calculated for a propeller behind a flat plate, using the Schultz-Grunow velocity distribution in the boundary layer.

Coming to the question of predicting ship power and propeller revolutions from the results of model propulsion experiments, it can be seen from previous work in conjunction with the present work that the hull efficiency of the "Victory" ship at 15 knots must in general be less than that of any of its corresponding models. In the case of the "D. C. Endert, Jr." the reduction in hull efficiency relative to an 18ft model, for example, amounts to some 12 per cent, and this reduction would presumably be greater for the actual ship. Can the authors confirm whether a similar trend has been observed in the self-propulsion experiments conducted with the "Victory" series?

Regarding the general question of ship-model correlation, it is not usual at present to modify the Q.P.C. as measured from the model experiments directly, but to accumulate information on the "ship correlation factor," defined as $D.H.P._{ship} \times Q.P.C._{model}/E.H.P.$, for a given ship speed. Since it has been agreed to calculate the E.H.P. for the ship based on a standard extrapolator we may attempt to

sub-divide further the Q.P.C. and inquire into the scale effects of its components. The general trends now appear to be:—hull efficiency of a ship is generally less than that obtained from its corresponding model; the longer the ship or the shorter the corresponding model, the greater the difference in hull efficiency between the two; in terms of " ship correlation factor," if the Q.P.C. derived from model experiments is corrected for the scale effects of wake and thrust deduction, then the derived ship correlation factor will tend to decrease with increase in ship length to preserve the ratio $D.H.P._{ship}/E.H.P.$ constant; and the efficiency of a propeller working behind a ship is generally greater than that of the corresponding model propeller.

The results of the propulsion experiments for the " Victory " series, giving the precise magnitudes of the scale effects of propeller efficiency, in conjunction with those already presented for wake and thrust, will help in indicating the most fruitful course of future research into these problems.

Mr. R. L. Townsin: Last week in Newcastle we heard a paper from Mr. Cutland, of the N.P.L., in which he presented information concerning some measurements he has taken in the boundary layers of two ships and underneath a pontoon. That paper also told us of some interesting measurements which have been made in the boundary layer of a model and in a propeller. Perhaps this is a tendency in modern research; and if we wish to gain information about the peculiar boundary layer effects we shall have to obtain many more measurements.

The concluding paper of the meeting was read on Thursday morning and was:—

THE EFFECT OF SURFACE ROUGHNESS ON THE PERFORMANCE OF A MODEL PROPELLER

By J. M. Ferguson

Synopsis

This paper investigates the effect on performance of a systematic increase in the surface roughness of a 24in diameter model propeller. The tests were made on behalf of the New Zealand Shipping Company, Ltd., and, at a later date, all results were made available to the British Shipbuilding Research Association. The effect of this variation in surface roughness on thrust coefficient, torque coefficient, efficiency and effective pitch is summarised in tabular and graphical form.

It is considered that these tests give a useful indication of the effect of surface roughness on the performance of a model propeller, but that quantitative application of the results to the full scale is extremely conjectural. The importance of the surface finish and condition of propeller blades is emphasised.

The results of more recent work on this subject carried out in Sweden, Germany, and Japan are discussed in an Appendix and are compared with the tests made at Clydebank.

Discussion

Mr. John Baird: At the beginning of 1952 my company was advised that one of its twin screw motor passenger vessels homeward bound from New Zealand would probably be two days late due to suspected heavy bottom fouling. The vessel was dry docked and it was found that the hull in way of the anti-fouling paint was in good condition and practically free from fouling. But there was a wedge of heavy shell growth on the boot-topping at the after end, and both propellers were covered by similar fouling. The two propellers were cleaned and polished, and before the vessel left on the next homeward bound voyage a diver cleaned the propellers.

The logs of these two voyages were analysed to assess the effect of the roughness of the propellers on propulsive efficiency. The logged wind forces were taken as a criterion of weather conditions, and the propulsive efficiencies of both the " fouled " and " clean " voyages were calculated and plotted against wind forces to obtain propulsive coefficients at zero wind velocity. The results indicated that for the fouled propeller there was a reduction of about 17 per cent propulsive efficiency, and it was assumed that the major proportion of this loss was due to propeller roughness.

By standardising speed and adjusting revolutions it was possible to obtain the revolutions for the clean condition and at zero wind velocity. The ship's speeds were then adjusted to the basic revolutions, and by again plotting on wind velocity it was found that the difference in speed between the clean and fouled conditions was 1 knot.

A propeller analysis for the clean and fouled conditions on a basic speed and revolutions deduced from the ship's logs showed that with the clean propeller the efficiency had to be reduced by about 3 per cent to obtain agreement between propeller chart and ship data. It was further deduced that the efficiency of the fouled propeller had to be reduced from the clean propeller by about 20 per cent, and the thrust coefficient by about 23 per cent, in order to reach agreement with the deduced propulsive co-efficients.

Mr. Ferguson's paper shows that the results in the ship are to a large extent reflected in the model propeller, although the propellers are of different characteristics. Metallurgy may do something to preserve the finished surface of the propeller, but if some coating could be evolved with anti-fouling properties and a smooth finish, such treatment would be complementary to the hull treatment and provide a solution to the avoidable waste of power.

Mr. R. N. Newton: Some similar work was carried out at Haslar, and referred to in the Parsons Memorial Lecture for 1957, prepared by Dr. Gawn. In this work a propeller was roughened by shot blasting. Compared with the tests described by Mr. Ferguson the amount of roughening was quite slight, equivalent to a grain size of 0·005in, yet it was sufficient to decrease the efficiency by as much as 14 per cent. This was due almost entirely to increase in torque coefficient, the thrust coefficient being very little changed, whereas in the experiments reported in the paper the thrust coefficient was considerably reduced. It would therefore appear that the precise method of roughening the surface of a model is not without considerable significance.

Maintenance of the clean hull, except by very frequent dry docking, is difficult, if not impracticable, with our present state of knowledge, and the cleaning of the propeller would need to be undertaken with due care. Such considerations promote thought as to whether the design of the propeller should not allow for a degree of fouling of the bottom and of roughening of the propeller blades, chosen to suit the particular service conditions of the ship. The point can be emphasised by a single example. For a 13,000-ton cargo ship in the trial condition of clean bottom and with a clean propeller, about 3000 s.h.p. is required for a speed of 13 knots. For the same displacement, but with the bottom fouled for six months at a rate of ¼ per cent per day, 4000 s.h.p. is required to produce the same speed. If in addition the propeller has become rough to a moderate degree of (say) 0·006in grit size, then the shaft horsepower for 13 knots is as much as 5700.

Professor E. V. Telfer: How do you use these very important results? I think we have to be in a position to analyse a rough propeller and a rough ship. One valuable feature of Mr. Ferguson's work, and the work of others, enables us to make the first step towards a reliable analysis. In one case that I remember we had a very heavily fouled ship and propeller, giving a 2½ knots loss in speed, and we sent down a diver to clean the propeller. The resulting difference was amazing. Previous to coming into Alexandria the ship could only turn the propeller at about eighty-five revolutions; when she came out the revolutions were about 115 and the speed increased by 1½ knots. For many years I have put an anti-fouling paint even on the best bronze propellers, and it does no harm.

The paper emphasises the importance of continuing with roughness investigations. One thing about roughness tests, both on hulls and propellers, is that they give results which appear to be free from all laminar flow considerations, and we get a greater consistency with rough results than with clean results.

Mr. H. Lackenby: The importance of the work presented is underlined by the fact that, since it was carried out, reports have appeared on three similar investigations made abroad. The " Lucy Ashton " tests showed that a difference in paint texture could be detected and that a light scattering of barnacles ⅛in high with some grass on the sides increased the resistance by 30 per cent.

There is some doubt as to how the model results should be translated to the full scale and we have tried to throw light on this by examining Mr. Ferguson's diagram comparing loss of efficiency shown in the German, Swedish and Japanese results and the results obtained at Clydebank. These four series of tests were carried out at different Reynolds numbers and we have tried to see whether the Reynolds number range between one investigation and another would throw any light on the scale effect problem.

In the Swedish tests the Reynolds number is about one-third that for Clydebank, and for a given relative roughness the loss of efficiency at Clydebank is noticeably greater, which suggests that there is increasing sensitivity to roughness with increasing Reynolds number.

In the Japanese model tests the Reynolds number must be about half the Clydebank value, in which case we might expect that the Clydebank results would again be more sensitive to surface roughness. This appears to be confirmed by the diagram.

The German tests were carried out at about twice the Clydebank Reynolds number and, oddly enough, the roughness here appears to be less sensitive. It may be that the roughness in these tests was not really comparable for varnish was used on the adhesive, and this may well have rounded off the sand roughness to some extent.

The only data that carry us some way beyond the Clydebank Reynolds numbers are the Japanese full scale tests, which cover a range about four times as great. Even these results measured on the Japanese harbour launch are still a long way from those appropriate to a full size ship as far as Reynolds number is concerned.

Nevertheless, there is some evidence to suggest that on the full scale the effect of roughness might be even greater than that shown by these model tests, which would underline the need for keeping full scale propellers as clean and smooth as is practicable.

It would be of great interest to know the quantitative effect of roughness on a full scale propeller and, in addition, to know how much roughness, if any, could be tolerated from the hydrodynamics point of view, without the propeller performance being affected significantly.

LETTERS AND LITERATURE

Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

TECHNOLOGY OF ENGINEERING MANUFACTURE

SIR,—I was lucky enough to be able to attend the recent Institution of Mechanical Engineers conference at Church House, and found the papers most interesting and stimulating. They also stimulated to expression a thought which has been brewing for a long time.

Technology of engineering manufacture, i.e. the making, to the highest economic perfection, of something which has been clearly defined elsewhere—all the papers took the product drawings as a starting point. How, where, and above all, by whom, has this definition been made ? It is expressed in the product drawings, as issued for manufacture, and these drawings—the only medium of transfer from thought to material—must contain, either explicitly or implicitly, all the vision, all the brain power and analytical ability, and all the skilled craftsmanship and experience that are available. We all know that these qualities can only get into the product through the working drawings ; but how do they get into the drawings ? Ah—this is not quite so clear. Quite obviously the draughtsman cannot be expected to do all this himself. Or is he ? Or is all this just supposed to happen by itself ? And who, at the higher levels, puts his signature clearly on the drawings as " approved for manufacture " and is prepared to stake his reputation on the result ?

Is it too much to suggest that this important matter deserves a good deal more attention than it has had in the recent past ? Perhaps one of the professional institutions—the Institution of Mechanical Engineers is perhaps most closely concerned—might consider, as a first step towards filling a serious gap, a conference on the technology of engineering design.

HUGH CLAUSEN

London, N.W.2,
April 4, 1958.

RAILWAYS INTO ROADWAYS

SIR,—Your correspondence column indicates a growing interest in railway conversion. An almost perfect opportunity of proving how good a trunk road can be when built on an abandoned double-track line, without major earthworks, is in process of being lost in my area. The Government have, on several occasions, stated that they are going to concentrate on a trunk road between the South Wales ports and the Midland area, of which the Ross Spur motorway, just started, forms part. The Abergavenny-Merthyr line has been closed from the beginning of the year, and runs parallel to the Heads of the Valleys Road which " is to be improved " on this trunk route. This road is steep, winding, and is dotted with narrow mining towns and villages and cannot be improved substantially without great expense and disturbance to private property.

It has been estimated that the cost of conversion would be approximately £29,000 a mile, about one-eighth the cost per mile of the Ross Spur motorway. Moreover, this line could be used as a by-pass for Abergavenny, a renowned bottle-neck.

With the apparent connivance of the Ministry, the B.T.C. immediately they got permission to close the line started negotiations with the landowners along the route to sell the old formation to them. These negotiations are far advanced. Need more be said ?

D. F. C. VOSPER

Llandovery,
Carmarthenshire,
April 5, 1958.

Book Reviews

Three Steps to Victory. By SIR ROBERT WATSON-WATT. Odham's Press, Ltd., 96, Long Acre, London, W.C.2. Price 30s.

THIS book is claimed to be a personal account by Sir Robert Watson-Watt—" radar's greatest pioneer "—of what its outside wrapper is bold to call " The Idea that Won the War," and the author his *Three Steps to Victory*. But what those three steps actually were the average reader might be puzzled to name. The author, however, lists them in their order of chronological conception as the " Instantaneous Visual Radio Direction Finder," " Radar " itself, and the practice of " Operational Research." They would have been less laborious to follow had radar's many forms been described in words, rather than indicated by alphabetical initials—such as C.R.D.F.—which are assumed to be understood by the ordinary reader at once, without being indexed at any one place in the book, though if, indeed, there be any such general key to the puzzle, it has certainly escaped our notice !

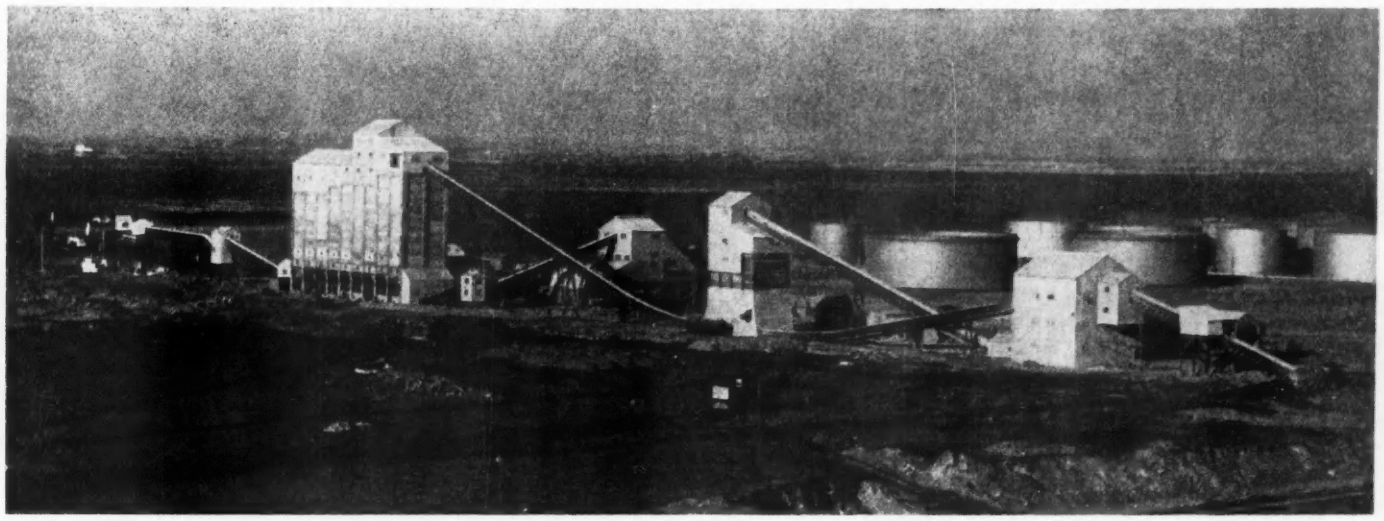
However, the date of radar's birth is no mystery, since it can be given at once as November, 1934, for then it was that the Air Minister of the day, acting on advice received from his Director of Scientific Research, created a " Committee for the Scientific Survey of Air Defence," with H. T. Tizard (now Sir Henry Tizard, F.R.S.) as its vigorous chairman, with three members to support him as well as a very purposeful secretary, A. P. Rowe. The three committee members were an eminent physiologist in Professor A. V. Hill, F.R.S., of University College, London ; the physicist Professor P. M. S. Blackett, F.R.S., of Imperial College, and H. E. Wimperis, the Air Ministry's first D.S.R. (with whom A. P. Rowe had for some years been in close touch).

The first meeting of the committee took place in January, 1935, and to this the then Superintendent of the Radio Department of the National Physical Laboratory (R. Watson-Watt) was invited to attend in order to give any evidence he could as to the possible potency of " wireless radiation," in one of its many forms, as a means for the defence of Britain from hostile Air Forces of any kind. It happened that Watson-Watt (like Appleton and others) had long made use of one form of such radiation in his meteorological explorations of the nature and position of the upper reaches of the earth's atmosphere, and he at once suggested to the committee (soon to be generally known as the " Tizard Committee ") a possible use of such technique for attack on the problem before them. After discussion it was decided that preliminary exploratory experiments were advisable ; these were promptly authorised and within a very few days certain very hopeful results were obtained. Thus was the infant " radar " born, and duly christened with its very apposite name.

The whole dramatic story was excellently related, with full personal knowledge, by A. P. Rowe ten years ago in his modest little volume *One Story of Radar* (Cambridge University Press). Although from this book any one interested could, it is true, have found a full and graphically told account of all technical matters, no sort of autobiographical side to the story was attempted; but the public now has this in full measure in the seventy-six chapters of the present book *Three Steps to Victory*, which, its author frankly admits, although intended as an autobiography, became what he terms a description of technical devices useful when human beings attempt to create " a vitally integrated operational system." This rather alarming objective turns out, however, to be more attractive than it sounds. Indeed, the author is in the end bold enough to repeat its claim of having been " The Idea that Won the War " !

The Air Department's " Committee for the Scientific Survey of Air Defence " of 1934, the " Tizard Committee," had a busy life for the years during which radar was steadily developed as a vital item in the Air Defence of this country, but met with some difficulties when Professor Lindemann (later Lord Cherwell and for some years a personal scientific adviser to Sir W. S. Churchill) was added to its membership. But by then the committee's task was largely completed and it had been given official association with the much larger, and far older, Committee of Imperial Defence, which, at " top-level," had the important task of advising the Prime Minister of the day upon any scientific problems which might arise in time of war.

It seems that Watson-Watt's individual concern with meteorological matters and the art of radio communication was largely an outcome of the events of 1914 and the war that followed. When that war began he was in London engaged on academic work, but the new demands took precedence and he soon received a call from Napier Shaw to join him at the Meteorological Office, in order to do some radio work having the objective of providing our early aviators with ample warning of the approach of thunder and lightning storms. This took him to the " Factory " at Farnborough, as the R.A.E. was then often called, and to which that war certainly drew many distinguished scientific volunteers. As the author of this book puts it—" I was fortunate to sit on the roof which covered such distinguished heads " ! Watson-Watt was in good company and " radar " certainly did prove itself to be one of the sure " Steps to Victory."



Slag Production Plant at Teesport

A plant with a capacity of 15,000 tons per week has been completed at Teesport for the preparation of blast-furnace slag for use as roadstone, concrete aggregate or railway ballast. The plant involves crushing, grading and storage, and is a good example of modern practice in the layout and control of plants of this kind. It also includes equipment for loading directly on to ships, and for coating the graded materials for "black top" construction for which two 60 cubic foot mixers are installed. The utilisation of slag is discussed generally in the introductory paragraphs.

THE utilisation of the waste materials of industry, and the avoidance of unpleasant accompaniments such as air or stream pollution, side by side with industrial operations, are becoming increasingly a national concern. Here we describe how one of those materials, produced in vast quantities and formerly a waste product, is being utilised in a constructive manner. Reduction of iron ore in a blast-furnace produces considerable quantities of slag, and the slag production from years of working can still be seen in vast heaps around many of the older iron and steel works throughout the country. But it is not so generally known that most of the slags produced to-day are marketable materials, and the tonnages which are consumed in a useful manner have increased very greatly over the past few years.

A few leading figures will illustrate the situation.* In 1957, about 7,000,000 tons of slag were sold. Less than 10 per cent of this quantity was slag from steel furnaces, and a relatively small quantity was from the reduction of apatite in the extraction of phosphorus. The great bulk of it was therefore blast-furnace slag. The corresponding figure for the total quantity of blast-furnace slag produced during the year was about 10,000,000 tons. This figure will, of course, increase with any increase in pig iron production, and it gives an idea of the expansion which is still possible in the markets for slag. By comparison, in 1948, the quantity of slag usefully consumed was about 3,500,000 tons.

The use which has been exploited most extensively up to the present is that of roadstone—for foundations or surface dressing, or as water-bound macadam, or alternatively coated with tar or bitumen for the various surfacings which are characteristic of coated construction. Other uses include ballast for the permanent way, filter media, and aggregate for concrete—either normal aggregate, from a plant such as we describe here, or lightweight aggregate which is produced by various methods of water-cooling the slag. Another important sphere of application utilises the cementing properties of slag, either by the production of blast-furnace cement, or in the Trief process.† These last uses—as a concrete aggregate, lightweight aggregate or as a cementing material—have not been so well developed as the other applications. They are more widely practised in the United States and in Germany, which, we are informed, accounts largely for the higher utilisation of slag in those countries—32,000,000 tons annually out of a total of 35,000,000 tons in the U.S. and the entire production in Germany. In fact, consumption exceeds production in Germany, and old heaps are being excavated.

Quality is ensured to-day by controlled methods of production and tipping. Much of the old slag, however, is of good quality, and is used for road construction, for reclamation or sea defence works. Slag resulting from some ores is unsuitable for applications such as those we have enumerated where chemical inertness is needed. But other uses are possible; for instance, certain slag which has a high lime content, is being tried out experimentally as a fertiliser—the basic slag fertiliser which is well known is, of course, slag from open-hearth steel furnaces, so this use would be a new one.

The Teesport Plant

The processes which must be carried out in the preparation of blast-furnace slag (the product must comply with British Standard specifications) are (*a*) tipping and cooling the molten slag, (*b*) crushing, grading and storing, (*c*) for "black top" work, coating with tar or bitumen. The tendency now is for all this to be done in a large plant, where economy in layout and in automatic control can exercise a worthwhile advantage over smaller installations. The plant just completed at Teesport is a good example of this trend. Production is 15,000 tons per week, and the material is graded in ten sizes. The main elements in the Teesport plant can most easily be appreciated by a glance at the drawing which shows the layout of the plant, and by the general view of it illustrated at the head of this article. The main plant is arranged in a straight line, extending beween slag pits and wharf, and the coating plant branches off at right angles to it.

The slag comes principally from the two new blast-furnaces of Dorman Long & Co., Ltd., at Cleveland. These two furnaces are part of a comprehensive scheme of development which includes a universal beam mill, and which has cost about £60,000,000. Needless to say, such a scheme could not be considered complete without a plant to process the slag. This plant is operated by Tarmac Roadstone, Ltd., and the principal plant installed in it has been supplied by Stothert and Pitt, Ltd., the latter firm also being responsible for plant design and for the control equipment. All the building and civil engineering work, including the construction of the bunkers and jetty, was carried out by Tarmac Civil Engineering, Ltd.

Before passing on to a detailed description of the plant, one or two outstanding points may be referred to. Advances in the design of quarry plant, and especially of coating plants, have been very considerable over the past years, and at Teesport, tendencies which were apparent in earlier designs have been developed even further. In particular, control of the various operations of the plant is largely automatic, and the labour force needed to run it is therefore small; reduction in labour was one of the basic aims of design. A second aim was to achieve consistent accuracy in the various screening and batching operations, particularly in the coating plant, where present-day practice demands a high standard. A third factor was the need for flexibility in delivering stone or coated stone from the plant according to varying requirements, and particularly for changing rapidly from one requirement to another.

The crushing and screening section of the plant can be controlled by a foreman and four men, one each at the feed hopper, mill house, selector screening unit, and main screening unit. For the operation of the coating plant a further two men are required, one for the two grading, heating and mixing units, the other at the lorry loading bays to deal with traffic to the six 20-ton mixed materials hoppers. Two men are required when ships are being loaded, one to set the feeders under the main storage bins, and one

* The British Slag Federation keeps such figures.

† See THE ENGINEER, October 25, 1957.

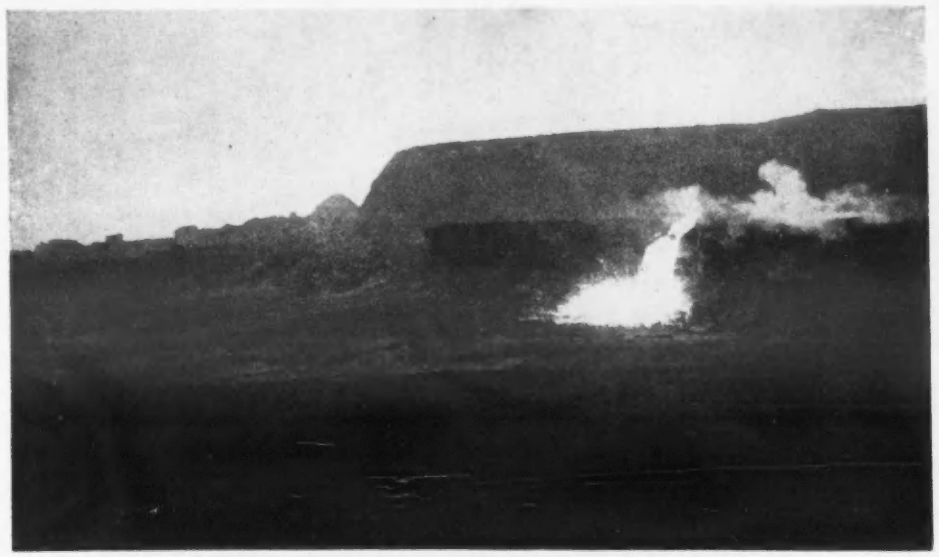


Fig. 1—Control over the tipping of the molten slag is important. Shallow pits ensure quick initial chilling. Here the commencement of a pour is shown

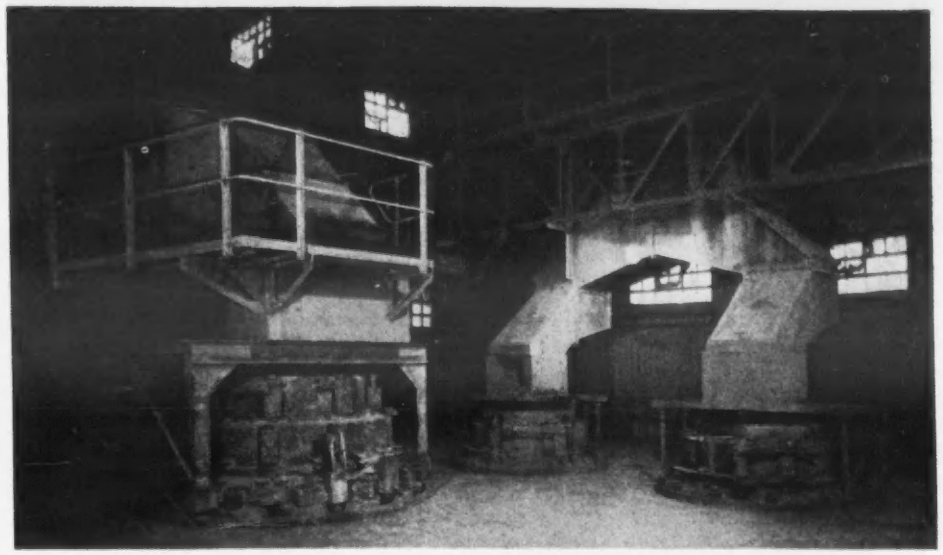


Fig. 2—Mill house interior. The primary crusher and two secondary crushers are shown

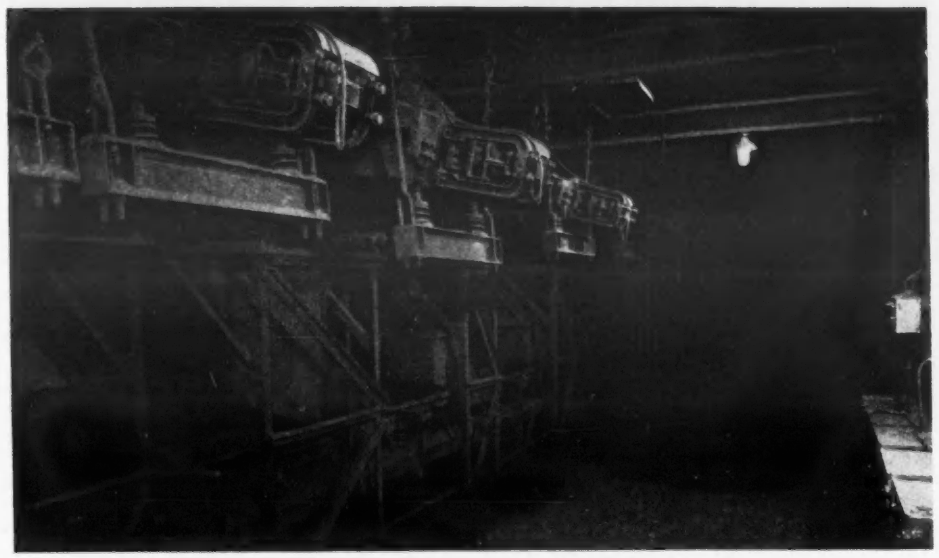


Fig. 3—Vibrating feeders in the selector screen house. Below the feeders, bifurcated chutes direct the material into one or other of the conveyors

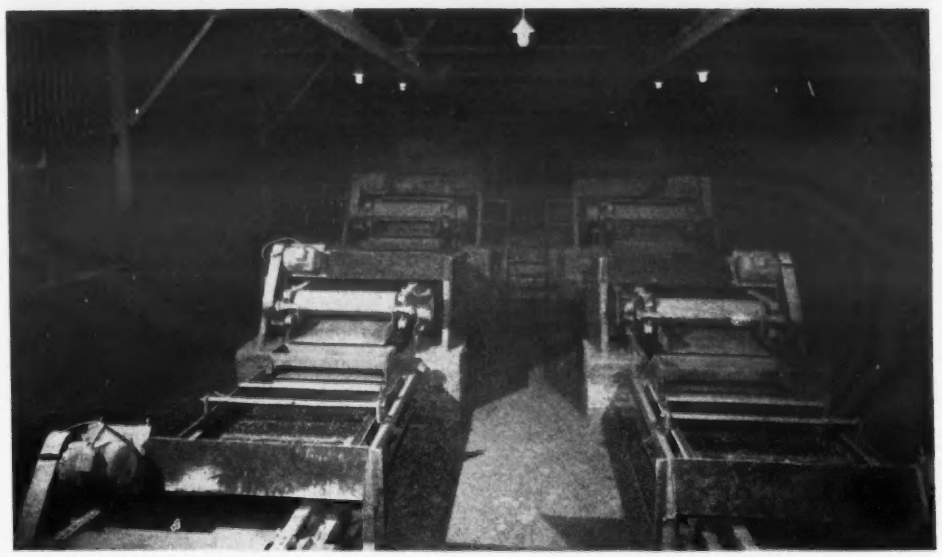


Fig. 4—Main screens, at the top of the main storage house. After preliminary sorting, the slag is graded into ten sizes by the main screens

for the wharfside conveyors and ship loading chute. This makes a total of a foreman and eight men when a ship is being loaded and the coating plant is in full production. In addition there is a staff of skilled technicians to attend to the maintenance and servicing of the equipment, and also the personnel involved in handling the slag before it enters the plant.

Accuracy and flexibility are achieved by the detailed layout, as described hereunder, but also by certain more general factors of design. The most noteworthy is the selector screening unit. Here, a primary screening is effected, and excess quantities of any specific fraction are returned to the mill house for recrushing. This has two advantages: the main screens are submitted to a constant load of material, since there is no recirculation from them, which results in more accurate screening and less wear on the screens; and the crusher installation is thus centralised and the crushed slag is handled more economically. The design of the coating plant also calls for comment; the complicated sequences of operations carried on here are controlled centrally, and for this class of plant standards of cleanliness and of layout for inspection and maintenance are high.

Direct loading into ships is also an important service effected by the plant. There is a berth, with loading conveyors, in the Tees, where ships up to 3000 tons can be loaded with graded slag and turned round in a tide. It will be appreciated that slag is competitive with natural stone in areas within a certain radius of the plant where it is produced. Transport by ships, especially in 3000 tonners, which are larger than vessels used previously for this duty and consequently offer more economical transport, extends this range. The Teesport plant will thus operate in conjunction with two plants on Thames-side at Deptford and Creekmouth and plants at Ipswich, Dover, Shoreham and Poole. Storage and distribution is carried out from these latter points, but the present scheme also includes the construction of a new plant at Deptford for the storage and coating of slag. Some of the Teesport slag, incidentally, is also exported to countries in Europe where indigenous roadstone is absent.

Slag Tipping and Cooling

Slag is run from the furnaces into 20-ton rail-mounted ladles, and then taken about three-quarters of a mile to the cooling pits of the slag plant. Wide pits with cross fall control cooling in the most convenient way, giving a quick initial chilling, and a layered bed of slag which an excavator can work easily. The cooling period is four to six weeks; we illustrate tipping in progress in one of the pits.

The trains of slag cars from the furnaces run on two sets of raised tracks between two cooling pits each 1900ft long by 125ft wide and having an average depth of about 10ft. When a train of cars reaches the selected discharging position power for the ladle tipping cylinders is supplied through flexible hoses from a mobile air compressor running on the adjoining track. Material is recovered progressively, working from one end of a pit whilst tipping proceeds at a distance ahead determined by the cooling time. The length of the pits is such that by the time tipping has been completed at one end of a pit, the opposite end has been cleared and recovery has progressed a sufficient distance for the tipping cycle to recommence. Slag is recovered from the pits by two 54 RB excavators and loaded into tipping lorries for transport to the crushing, screening and mixing plant.

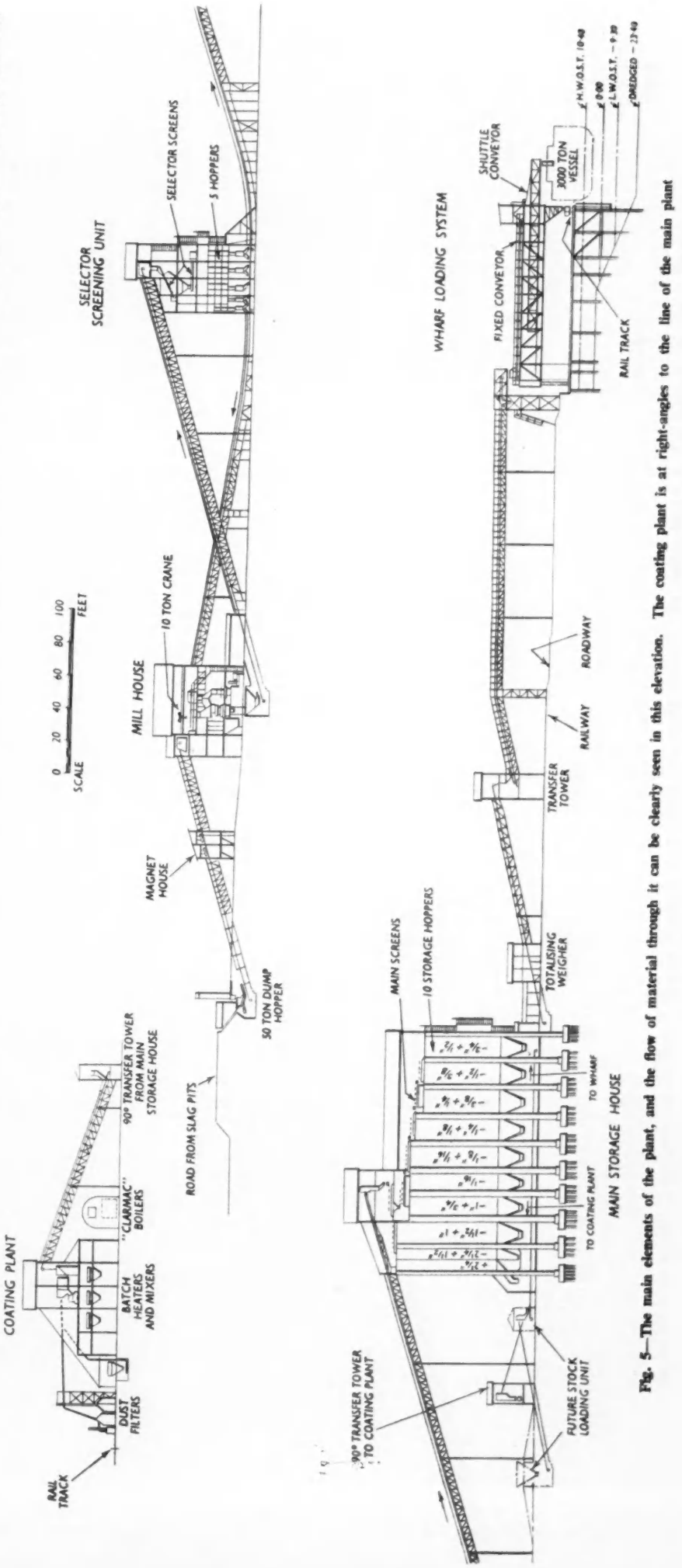


Fig. 5—The main elements of the plant, and the flow of material through it can be clearly seen in this elevation. The coating plant is at right-angles to the line of the main plant

Mill House

Lorries discharge the slag from the cooling pits into a ground hopper of 50 tons capacity. A vibrating feeder (controlled remotely from the mill house) on this hopper passes the material at a controllable rate up to 300 tons per hour on to the tail of a conveyor. This conveyor carries the material to the top of the mill house. During its passage up the conveyor the material passes under a magnetic separator which removes any tramp iron. Before primary crushing much of the material would pass a 4in screen. The largest cube size generally delivered is about 8in but occasionally slabs up to 24in long are encountered.

Three Symons cone crushers are installed in the mill house—a 5½ft primary coarse machine and two 4ft short head machines—and they can be seen in one of the photographs we reproduce. The largest of these machines is fitted with wedge adjustment for quick setting and is driven through a "Twiflex" clutch mounted on a jack-shaft coupled through a countershaft and vee rope drive to the motor. Each of the two 4ft secondary crushers is driven through a "Twiflex" clutch on its motor shaft with a vee rope drive to the crusher countershaft.

Material is discharged from the conveyor on to a 72in by 144in single deck "Gyrex" screen with 4in square mesh. The −4in material is delivered by chute to the tail of the main discharge conveyor from the mill house. The +4in material is crushed in the primary machine and discharged on to the same chute. The purpose of the two secondary crushers which also deliver into the common chute will be mentioned later.

Selector Screening Unit

The crushed material from the mill house is elevated on its conveyor and delivered to the selector screening unit. At the top of this unit the material is discharged through a breeches chute to two sets of screens. Each set consists of a double deck 72in by 192in "Gyrex" screen and a 60in by 192in Symons single deck screen. Two cuts are taken from the double deck screen and three from the single deck screen, including the reject over the end, making a total of five sizes. The screens are mounted above a five-compartment storage bin, each compartment of which has a capacity of about 100 tons. The screens separate the material into the following sizes for delivery into the storage compartments: −4in+2½in ;−2½in +1½in; −1½in+¾in; −¾in+½in; and −½in. An electrically-operated vibrating feeder is fitted at the bottom of each compartment.

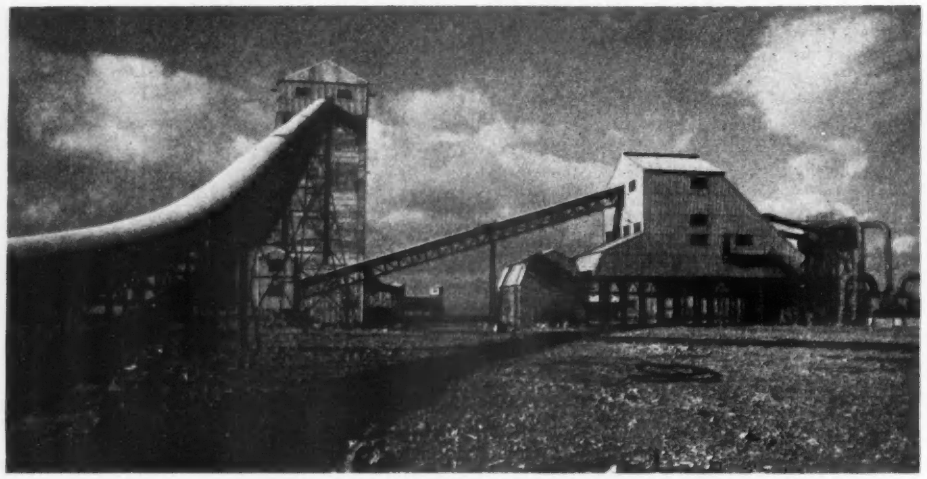


Fig. 7—The coating plant, with the main storage house on the left. Two 60 cubic foot mixing units are installed in the coating plant

On the four compartments for +½in sizes materials discharge through bifurcated chutes. One leg of each bifurcated chute and the −½in discharge chute deliver on to a conveyor leading to the final screening plant at the top of the main storage house.

The other legs of the bifurcated chutes deliver on to a second conveyor leading back to the mill house. The bifurcated chutes are fitted with "Thrustor" operated diverting plates which are actuated to deliver the material on to one or other of the conveyors. These chutes and the vibrating feeders can be seen in our illustration (Fig. 3). Thus, when there is an increased demand for the smaller sizes of material, any selected size can be returned to the mill house for re-crushing in the two 4ft secondary cone crushers. The recrushed material then re-joins the first delivery conveyor for return to the selector screening unit.

With this arrangement of what may be termed closed circuit selecting and recrushing there can be sent forward to the main storage hoppers a bulk of the particular sizes required together with the −½in fraction. It may be required, for instance, to produce a quantity of −4in+2½in material but to reduce the bulk of the throughput to small sizes. In such a case the primary scalping screen will enable the −4in material in the feed to be taken directly to the selector unit leaving the primary crusher to be adjusted, if required, to a setting suitable for the final production of the finer fractions. This arrangement will allow the production of a quantity of larger material whilst the primary crusher works at an efficient setting for the requirements of the bulk of the throughput. If required, the whole of the 300 tons per hour throughput could be reduced to −¾in and it is estimated that of this total about 220 tons would be −½in.

Panels with push-button control and tonnage indicators are mounted next to each of the feeders of the selector screening unit.

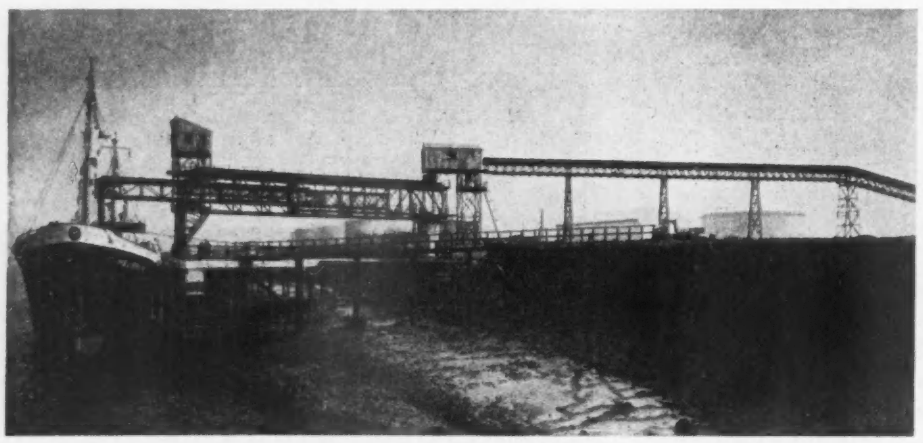


Fig. 6—Loading jetty. Note the telescopic loading conveyor. The wharf-side support is on wheels on a curved track, and the conveyor bridge can pivot about the concrete column, to load the various holds of the vessel

Main Storage Unit

The main storage hoppers are approximately 90ft high and are constructed in reinforced concrete carried on *in-situ* piles. It was impossible to drive piles satisfactorily through the depth of slag overlying the site and it was necessary to excavate to a depth of 15ft before piling commenced. The ground floor slab was then suspended on columns and beams and the whole area backfilled. The method used for the construction of the bunkers is of considerable interest. Precast wall panels in 2ft 6in lifts were set in position and the columns then cast *in situ* to the same level. This enabled much of the concreting work to proceed in the early stages and, once the walls had commenced, progress was found to be very rapid. The hopper bottoms are lined with steel plates to reduce wear and to prevent materials building up and hanging in the bunkers. The hoppers carry the main screens on top of them and the overall height of the building is approximately 120ft.

During the construction of the foundations crushed slag was used as coarse aggregate for some of the concrete work; mixes were easily obtained with workability and crushing strengths equal to those obtained with natural aggregate.

Final separation at the main screens is into ten sizes and is done by fourteen single deck Symons screens; the hoppers vary in size according to the sales requirements anticipated. They incorporate compartments to take 545 tons of −4in +2½in; 560 tons of −2½in +1½in; 1175 tons of −1½in +1in; 1035 tons of −1in +¾in; 840 tons of −¾in +½in; 925 tons of −½in +⅜in; 980 tons of −⅜in +¼in; 1085 tons of −¼in +$\frac{3}{16}$in; 1290 tons of −$\frac{3}{16}$in +⅛in; and 1210 tons of −⅛in, a total of 9645 tons. The screening section at the top of this house can be seen in Fig. 4.

Each of the ten main storage hoppers has two outlets at the base, each line of ten outlets delivering on to a separate conveyor system—one system being for direct delivery to the loading wharf and the other to the coating

plant. For loading into railway wagons or lorries there are chutes fitted along one side of the row of hoppers; the chutes are manually operated.

The ten outlets serving the wharf conveyor system are each fitted with a " Locker " electric vibrating feeder with a capacity up to 250 tons an hour. By selecting the sizes and setting the feed rate any required combination of materials can be delivered to the conveyor up to a total of 400 tons per hour. The conveyor is fitted with a Blake-Denison totalising weigher at the outgoing end of the house and it elevates the material to deliver it to a second conveyor at a transfer tower. This second conveyor delivers the material to the loading wharf conveyor installation. The transfer tower will be used later on to divert materials to a stockyard. When this stockyard is brought into use, a stock loading unit will be built, just prior to the main storage house, as shown in the drawing.

The second row of ten outlets serves the conveyors leading to the coating plant. The outlet for the largest fraction is controlled by an electric vibrating feeder with a maximum feed rate of 110 tons per hour. The other nine openings in this row are controlled by 60 cubic foot rotary metering feeders, or " graders " as they are sometimes called. These devices give a more accurate proportioning of material from the storage bins; an error of $\pm\frac{3}{4}$ per cent is not exceeded in normal operation. The slag is drawn off in batches, each batch with the correct proportion of each fraction delivered by the various graders, and the complete batch is delivered to the hoppers of the coating plant, where it is check-weighed. Delivery of these batches is controlled from the coating plant, and is described further on.

Loading Wharf

The conveyor installation serving the wharf is of particular interest in that it has been designed to deposit and distribute material in the holds of a vessel along any part of its length without moving the vessel along the quayside as loading progresses. To make this possible the loading installation is in the form of a bridge spanning 98ft which is arranged to pivot about the end on which the conveyor receives the material. At its outer end this bridge is supported by a column structure carried on a curved track by two carriages in such a way that it can be slewed through about 90 deg. Within the bridge there is a separate conveyor mounted on wheels and guided so that it can be telescoped by a rack and pinion gear to deposit the material it receives from the fixed conveyor through a chute into the hold of a vessel. Thus, material can be deposited into any hold along the length of a vessel (the conveyors cover a length of nearly 200ft measured at the centre line of the vessel) without the delays hitherto experienced in moving the vessel to bring its holds into the loading position in respect to a fixed chute.

A cabin at the delivery end of the slewing conveyor is equipped with a central control panel from which the storage hopper feeders in the main storage house are started and stopped. The cabin gives a clear view of the loading operation, enabling the operator to pivot the conveyor bridge, extend or retract the telescopic conveyor and lower or raise the delivery chute to the holds. A remote rate indicator and totaliser indicate in the control cabin the measurements made by the weigher. The storage hopper feeders are started and stopped only from the cabin, and must first be selected from the main storage house; indicator lights in the cabin show which feeders have been selected.

The conveyor installation is carried on a reinforced concrete jetty projecting 110ft into the river. To allow 3000-ton boats to use the jetty extensive dredging was carried out, over 100,000 hopper yards of materials being removed. The jetty consists of a heavily reinforced concrete slab carried on steel piles driven into the marl underlying the site.

Coating Plant

The coating plant is positioned at right-angles to the line of the main plant, and so is shown as an inset in the elevation of the plant illustrated in the diagram; it is also illustrated on page 580. It consists of two heating and mixing units, each of 60 cubic foot capacity, set side by side. The graded batches of material are conveyed from storage to a bifurcated chute delivering into one or other of the weigh hoppers of the two units which check-weigh the complete batch. The sequence of operations is then as follows. The batch passes from the weigh hopper, through a " Thrustor "-operated door to the heating drum. After heating, a pivoting-chute, which is operated by an electric motor, opens and transfers the batch to the mixer, which, as is customary, is a paddle mixer. Here, binder and flux if required are added as a spray, in measured quantities, and filler is added for some mixes. The batch may be discharged from the mixer (the discharge door is also operated by an electric motor) directly into lorries or into one of three " mixed-material " hoppers. The set of three hoppers is mounted like an overhead travelling crane, one such travelling unit serving each mixer and traversing across the loading bays. The capacity of each of the hoppers is 20 tons.

It should be pointed out that the " filler " added at this stage is not produced in the main plant, but is brought in to supplement the " fines " already available. It is delivered by lorry, into a ground hopper, and transferred by a " Redler " elevator of 9 tons-per-hour capacity, to a service hopper which has a leg serving each of the two mixers, with a capacity of about 2 tons available for each of them. A weigh hopper weighs the given quantity of filler, which is then discharged into the mixer through a helmet door.

Various other services must be provided at the coating plant. Binder is heated in " Clarmac " heaters (three of 6000 gallons and one of 4000 gallons) and flux is stored in two 1000-gallon tanks. These materials are metered before they enter the mixers by automatic devices commonly used for this duty. Four binders are catered for in this plant and this enables the plant to produce material to any required specification.

An alternative mode of operation utilises the plant for the production of water-bound macadam, so water also can be added and metered in one of the mixers. Fuel oil is stored in two 1000-gallon tanks, and again its delivery is controlled according to the heating cycle. A compressor with a capacity of 48 cubic feet of free air per minute forms part of the plant, and powers the pneumatic devices—binders and filler meters, and pneumatically-operated doors; the operating pressure is 80 lb per square inch.

Control of Coating Plant

It will be appreciated that automatic control of the coating plant is somewhat complex. The brief outline of its functions which we have just given indicates the various measurements—batching, weighing, metering and temperature and time control—which must be effected for each batch, and which might well have to be varied from batch to batch. Further, the two mixers may well be mixing simultaneously to differing specifica-

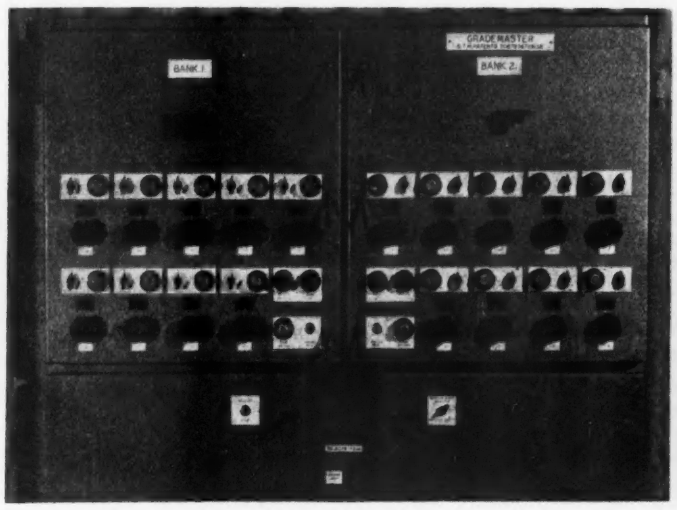


Fig. 8 (left)—Control panels for proportioning the batches discharged from the main storage house. One panel serves each of the two mixing units. Fig. 9 (right)—The control desk is similarly divided into two sections, and has timing dials on which the durations of various operations are preset, as well as the operating buttons and lights

tions, so the whole train of events must be protected by electrical interlocks so that the correct sequences are followed and yet maximum capacity is achieved by the two mixers.

The mixing plant will, in fact, produce a variety of coated mixtures at a rate of 150 tons per hour under favourable conditions.

Batches follow each other through each mixer of the plant, with one in the mixer, one in the heater, and one in the check-weigher hopper. A train of seven batches (i.e. the quantity to fill one mixed materials hopper) can be initiated entirely automatically on pressing a button, and then the whole cycle repeated by pressing it again. All controls are grouped on a control desk and a setting panel, one set of controls serving each mixer unit. The accompanying illustrations show these controls. However, control may be automatic, semi-automatic, or by hand control for sectional operation or maintenance.

The two banks of setting controls govern the proportioning of the various fractions in a batch, and hence control the graders at the main storage hoppers. In each bank a dial is incorporated for each fraction, and is set to show the percentage of that fraction delivered on to the belt. Upon instigation of a batching cycle the total must be 100 per cent before the cycle can be started. The main dials are graduated in 5 per cent increments, with an adjustment for superimposing 2½ per cent on any given reading.

The main control desk is likewise divided into two banks and it incorporates, in addition to the control switches, dials on which the specified times of the operations in the mixing cycle are set and a batch counter and batch totaliser in each bank. Having placed a measured batch of materials on the conveyors, from the settings on the panel just described, the essential measurements and controls as the batch passes through the plant are as follows: check weighing in the weigh hopper; discharge to heater; heating for a given time; discharge to mixer; addition of metered quantity of binder, and flux simultaneously if required, at a given time after the start of discharge into the mixer; weighing filler; addition of filler at a specified interval after the addition of the binder; mixing for a given time after addition of the filler; discharge to lorry or to a hopper positioned by a selector switch.

Opening and closing of all doors is controlled automatically and interlocked to ensure that the preceding batch is clear of the next stage. The binder meter resets automatically after discharging the metered quantity into the mix. The oil consumption of the heater is recorded as a total and as rate of flow; the flame is reduced to a "pilot" flame when the heating period is completed, and restored when a new batch is introduced. It is now normal practice to add a photo-electric device to heaters such as these, which re-ignites the flame if it should be extinguished.

In semi-automatic operation the grader panel push button is depressed to bring a batch to the selected weigh hopper. The weigh hopper door button is then depressed to initiate the automatic passage of the batch through the heating and mixing unit for ultimate discharge from the mixer. In hand operation, individual push buttons are depressed to initiate batches from the graders to the weigh hopper, to discharge the weigh hopper to the heater drum, to discharge the heater drum to the mixer, to add binder and flux, to add filler and to discharge the mixer. The measurers and filler hopper automatically recharge whilst the doors and chutes automatically return to the closed or out positions.

Control and selection of the travelling hoppers and the direct discharge chute in the loading bays is made at the desk and a warning light indicates to the man at the loading station that the travelling hoppers are about to move. These hoppers are fitted with pneumatically-operated doors, fitted with electric heaters, and are under the push-button control of the man at the loading station.

Dust Suppression

In conclusion, one or two general points about the Teesport plant may be remarked upon. Various devices such as the "graders," binder meters, automatic doors, &c., have not been described in detail, for although they are somewhat sophisticated mechanically, they are generally of standard design for a plant of this kind, and we have concentrated upon the general conception, which has more novelty.

No mention has been made so far of the attention given to dust suppression. The first illustration, at the head of this article, in fact shows the plant in full operation, though little dust is visible. The illustration of the main screens, too, shows a fairly clear atmosphere. In the main section of the plant, water sprays have been installed at various points to keep the moisture content of the slag high enough to lay the dust. A wetting agent is added to the water. The sprays are at both ends of the first conveyor (i.e. at the ground hopper and the mill house), at the tail of both conveyors, between the mill house and the selector screens, and at the tail of the conveyor between the selector screening unit and the main storage house. In the coating plant, extractor fans serve the building, and discharge through filters where the dust is recovered, and can be used as filler.

Another important element in the plant is a laboratory where routine tests of roadstone products are carried out. There is also a fitting and maintenance shop, and a sub-station, and welfare facilities for those employed there have not been neglected.

The construction of the plant was carried out by the following contractors:—Main plant, Stothert & Pitt, Ltd., Bath, who sub-contracted the conveyor construction to New Conveyor Company, Ltd., Smethwick; building and civil engineering work, Tarmac Civil Engineering, Ltd.; dust extraction equipment Joshua Bigwood & Son, Ltd., Wolverhampton; dust suppression equipment, Stuart B. Dickens, Ltd., London; electrical installation, B. French & Co., Ltd., Kidderminster. The whole programme was carried through under the direction of the development department of Tarmac Roadstone, Limited.

Conference on Technology of Engineering Manufacture

No. II—(*Concluded from page 535, April 11*)

Sixty papers were presented at the Conference on Technology of Engineering Manufacture arranged by the Institution of Mechanical Engineers and held from March 25 to 27 last. We continue below our abstracts from the introductory notes of the reporters at the sessions dealing with the forming of materials, the machining of materials and inspection techniques.

Extrusion

DR. D. F. Galloway describes some recent experiments on the impact extrusion of aluminium, copper and steel. Impact extrusion has received a fair amount of attention from the research workers in the last few years but a complete explanation of the process still eludes us. It is, I think, well established that impact extrusion has distinct advantages over slow extrusion in the amount of work done and the extrusion ratio possible.

Some limiting factors in the extrusion of metals are discussed by Messrs. Hirst and Ursell. Their considerations relate more specially to hot extrusion of non-ferrous metals, but the principles are of general application. Even if the melting limits would not normally be reached in cold extrusion, one might suppose that much of what they say applies to cold extrusion also.

The cold extrusion of metals is the subject of an experimental programme at M.E.R.L., and the paper by Messrs. M. T. Watkins, K. Ashcroft and J. McKenzie describes some of the results obtained.

The paper on sintered metal machine components by Mr. G. R. Bell naturally fits into this session by contrast and as a possible competitor for the forging and general deformation processes with which this session mainly deals. In paragraphs on improvements in, and aids to, production, Mr. Bell emphasises the importance of better metallurgy in eliminating machining operations. But, in fact, the same remarks apply to precision forging operations, and the real competition would seem to be between powder metallurgy and forged components. He points out two other fields at present not exploited—the substitution of sintered parts for small grey iron castings on which normally considerable machining has to be done, and the use of sintered metal for highly stressed components, a market which is now being developed in this country.

The author gives facts and figures of the production of metal powder and sintered parts and shows a picture of a rapidly growing industry. He gives examples of the wide range of parts which may be made, and shows interesting diagrams for the design considerations which are involved when preparing for sintered metal production of small components.

Rolling

Mr. R. Stewartson reviews the progress in rod and bar rolling since 1945 in an informative paper which illustrates the importance of plant layout of what is usually called the auxiliary equipment of the rolling mill, but which this paper shows to be of vital importance in both production and the quality of the product. The rod mill stand pass has to a large extent become standardised, and although there seem to be some changes in pass sequence, these changes will be argued about by rolling pass designers as long as there are roll designers.

Mill layout development is inevitably towards single-stand continuous line operation, following the same path as the continuous strip mill, but with the added complication that in doing twist passes the

stands require to be alternately horizontal and vertical. This is to be credited to this country, but it would seem from Mr. Stewartson's paper that the forward thinking in nearly all other respects is being done elsewhere. In the more conventional layouts, however, the tendency has been to increase the number of stands up to four. This has been at the cost of some loss of accuracy, and Mr. Stewartson discusses this aspect and the general question of yield.

From continuous rod rolling to the continuous strip mill is perhaps the logical sequence, and the next paper by Ball and Starling gives some account of the scheduling and operating problems of high-production flat rolling. This paper emphasises the overriding preoccupation of the steel works engineer—the problem of how to get the almost astronomical quantities of raw materials into the steel works, to keep them flowing through the works, and then to get rid of them at the other end. When mill finishing stands deliver strip at 6000ft a minute and with the necessity for keeping reasonable buffer stocks, the proper scheduling and identification of new orders becomes a major organisational activity. These problems are admirably described in the paper. The authors set out a forecast of future developments in sheet production. These appear to be aimed at direct manufacture of steel from ore and also continuous casting processes. But they also indicate that developments of the conventional plant are already envisaged or under erection. On the metal forming side, the most likely development is the coupling of the strip mill to the rest of the processing line to give virtually a continuous strip through to the final cut-up line.

In concluding Professor Ford said : I have had very great pleasure, indeed, in studying these papers, and I think the main conclusion to which one inevitably comes is that in these developments of metal forming as against metal cutting processes the lines of demarcation between different forming processes are becoming more and more diffuse. One finds the open forging, extrusion, impact extrusion, piercing and upsetting processes being combined to give a much more varied possibility to the mechanical engineer in the development of accurate components.

Machining of Materials

Two sessions of the conference were concerned with the machining of materials, and the first session was held under the chairmanship of Sir William Stanier. The reporter for this session was Dr. W. A. J. Chapman, who said : I propose to deal with the papers in the order in which they appear on the programme, because that will mean that the papers on cutting will be interspersed with rather lighter material relating to other fields, and this will provide a little light relief from the technical aspects of some of the cutting papers. I feel that the investigators of cutting techniques take life rather seriously, and their papers tend to reflect that attitude.

Mr. A. W. J. Chisholm (" Review of Some Basic Research on the Machining of Metals ") begins by saying that the past fifty years have seen a considerable amount of research, which has been stepped up during the last twenty. He deals with idealised cutting processes, beginning with chip formation, which is divided into oblique and orthogonal. Oblique is the ordinary round-nose tool cutting, and orthogonal is where the cutting edge is perpendicular to the cutting direction. He discusses the work of various investigators and says that the continuous process of chip formation is the easiest to consider, but he discusses later the discontinuous process. Under " Chip Friction," he says that the nominal contact pressures are high, being of the order of 100,000 lb per square inch when cutting steel. He deals with the effect of cutting fluids and of tool material.

After referring to chip thickness, and shear strength of the work material, he deals with conditions of deformation and the work of various investigators who have found that the operative mean shear strength remains substantially constant over a wide range of cutting conditions and appears to be affected mainly by the undeformed chip thickness.

The author maintains that the machining force depends on the interaction of several factors and is not proportional to the hardness or the shear strength of the material. He points out the difficulties inherent in this work of the determination of the temperature distribution and says that there is still much work necessary in this and allied fields.

He deals briefly with the discontinuous chip, the oblique cutting process, the built-up edge and the machined surface, and the incidence of the built-up edge and its effects.

Mechanics of Metal Cutting

Professor N. N. Zorev's paper (" Certain Results of Work in the Field of the Mechanics of the Metal Cutting Process ") is extremely well-written and presented, with diagrams and references, and admirably translated. I feel that it may cause a little heart-searching amongst investigators of cutting. He says in his introduction that plastic deformations play the most important part in the cutting process, since they predetermine the course of the other phenomena, and consequently the cutting process as a whole, to a considerable extent, and he adds : " Study of the influence of the cutting conditions on the magnitude, direction and rate of plastic deformation, and also on the stress, force and work necessary to produce it, is one of the basic tasks set by the mechanics of the process."

He goes on : " The case where building up arises at the front face "—that is, the built-up edge—" causing secondary plastic deformation of the lower layer of the chip, is more complicated." He refers to a number of research projects, and adds : " However, the results of these projects do not conform to the necessary degree with experimental data even for the simplest case of cutting."

Plastic displacements, he says, do not proceed on one plane alone, but on a number of planes, and he develops a mathematical expression which embraces the three factors. He says : " For a given rake angle, the angle of action is determined by the mean coefficient of friction between the chip and the front face of the tool. Therefore, the effect from all the cutting conditions is linked with change in the mean coefficient of friction."

He describes the detailed research which has been carried out, in connection with the great part played by the mean coefficient of friction in the cutting process, into the laws governing alterations in and the physical nature of this mean coefficient, and says that it was established as a result that two types of contact process exist : (i) when the frictional stress is less than the shear strength, and (ii) when the frictional stress is greater.

The author then discusses build-up, and says that it has been shown that " in the field of very deep cuts, as a result of the occurrence of the built-up nose, the effect of all the cutting conditions acquires a totally different nature." He adds : " It has been established experimentally that a built-up nose can exist under cutting speeds of any degree of slowness, provided that the mean coefficient to friction is sufficiently high. It has thus been proved that the occurrence of built-up nose is not connected with temperature, as is normally assumed."

In his paper, Mr. L. V. Colwell (" Residual Stresses in Metal Cutting ") says that former practice in the automotive industry in the U.S.A. was to allow castings and machined parts to be aged to relax both machining and casting stresses, and that until recently " most research in this area has been directed at the effects of residual stresses on the functional qualities of manufactured products with little attention being given to metal-cutting processes as causes." He adds : " The majority of publications treating residual stresses in metal cutting are concerned with grinding ; there are very few devoted to what might be called ' thick-chip operations.' " He goes on to deal with work-hardening by hardness measurements, work-hardening as determined by X-ray analysis, dominant stress, by warpage or specimen distortion, and stress distribution, by differential metal removal.

Messrs. J. P. Brown and A. M. Laws (" The Role of a Metal Cutting Research Laboratory in a Large Engineering Company ") say that the metal cutting laboratory with which they are concerned is a small section of the research department. The total cost of machining in the company has been estimated to be £2,700,000 per annum, of which £900,000 could be attributed solely to the process of removing metal. The authors describe the equipment used in the laboratory and the cutting test procedure, and they conclude by saying, "The machine tool is receiving increasing technical attention, while the use of the cutting tool is still based largely on tradition."

Dr. E. M. Trent (" Developments in Turning and Single-Point Tools, with Particular Reference to Developments in Cutting-Tool Materials ") says that during the last twenty years a great deal of effort has been devoted to research in metal cutting ; techniques of measuring stresses and temperatures in cutting tools have been considerably developed and much thought has gone into analysis of the mechanics of the cutting process and the distribution of heat in the cutting tool. The part played by cutting-tool material has been relatively neglected, but is now being investigated with modern methods, such as radioactive isotopes and the optical and electron microscopes.

He deals with the properties of tool material, flank wear, cratering, build-up and deformation. He considers chemical inertness of the tool in relation to the work material to be of primary importance where a built-up edge is formed, and says that the introduction into tungsten carbide-cobalt tools of some titanium carbide weakens the bond between the steel and the tool and reduces the build-up, while on ceramic tools it is eliminated altogether. The highest temperatures in a tool tip are located near the nose. A small nose radius or a small plan angle leads to high temperatures near the nose. He then refers to mechanical shock and thermal stresses and goes on to discuss in an interesting way the types of wear and the properties of a tool material which are required to be most effective against it.

Dealing with the changing requirements for cutting tools, he says that " partly because tools capable of cutting at much higher speeds seem to be increasingly brittle, the trend to higher speeds, although continuing, is probably not now the main direction of development in cutting tools." The demand for the harder and more wear-resistant tool

materials will increase, but this does not mean that high-speed steel, cast cobalt-based alloys or the softer grades of carbide will become obsolete. Tools capable of being used at cutting speeds higher than the best in use to-day will be required, but the demand for these will probably not be so urgent as the demand for better tool life at existing speeds. It seems probable that major developments in tool materials will come as a result of fundamental studies of the structure and properties of hard alloys and of the cutting process.

Mr. Brewer's paper (" Turning with Ceramic and Sintered Oxide Tools ") is introduced by a description of the properties of ceramics and the types available. In a very interesting table he summarises all the known ceramics and gives useful information. He then deals with the essential points in the manufacture of ceramic tips and the methods of utilising them. One claim often made for ceramics and sintered oxides is that there can be no built-up edge, but this is not necessarily so. The paper of Messrs. D. A. Wight and J. K. Church (" Specification of Tool Shape and the Grinding of Cutting Tools ") is first devoted to methods of selecting suitable tool shapes by considering the geometry of the cutting edge, and the authors consider the basic geometry under the headings of normal rake, effective relief angle, side cutting-edge angle, plan relief angle and tool nose form, and produce some interesting and simple curves to show the effect of these factors. On the grinding of cutting tools they then say that the tool should be withdrawn for regrinding at the stage where the rate of wear commences to increase, and that it has been found from experience that this stage is reached when the width of the flank wear is between 0·030in and 0·040in on carbide tools and between 0·040in and 0·050in on high-speed steel tools. They go on to deal with tool-grinding techniques and advocate controlled tool grinding, by which, within a year, the weekly turnover of carbide lathe tools was reduced by approximately 40 per cent and the breakage of standard tools by about 75 per cent.

Mr. D. McL. Grant's paper (" Technique of Hydrabrasion ") describes it as a process dependent upon the high velocity discharge of fine particles of abrasive suspended in a liquid. The nature of the work done to the surface will be partly the production of an indentation and partly the removal of a little material. There are three principal factors which determine the work capacity of an abrasive stream : (1) the component of velocity of the stream normal to the surface at the instant of impact ; (2) the concentration of abrasive, and (3) the specific gravity of the abrasive material. The author discusses the nature and properties of hydrabraded surfaces. One of the most far-reaching properties is its wettability. If a freshly-hydrabraded surface is dried and placed on end in an extremely thin oil film, capillary attraction commences at once and the oil will climb the surface. When oil has been introduced to such a surface, it is impossible to remove it except by soaking it in a solvent or by burning it off. Metallic components, when treated with preservative oil after hydrabrasion, may be kept indefinitely.

Mr. W. S. Hollis's paper (" The Machining of Titanium Alloys ") is very comprehensive, with many diagrams and tables. Titanium is relatively light, 0·16 lb per cubic inch, with an ultimate strength of 60–73 tons per square inch. Its corrosion resistance is notably high. He discusses the alloys which are available and goes on to deal with the general characteristics of machining titanium alloys, mentioning the pronounced tendency to gall and to work-harden. The galling characteristic promotes chip weldment and rapid build-up on the face of the tool, and this in the case of carbide-tipped tools produces continued fragmentation of the cutting edge. Both carbide and high-speed tools suffer from excessive flank wear. The cutting speeds which can be adopted are considerably lower than those associated with steels of comparable yield strength. The reason for the adoption of lower speeds is mainly the inability of the metal to disperse the heat energy produced by the cutting process. Tool life even for carbides under the cutting speeds imposed is extremely low. The maximum machining speed for workshop use is reached at about 120 surface feet per minute, with comparable speeds for the other alloys.

The author then deals with single-point machining with high-speed tool steels and says that titanium alloys present a much greater problem than the relatively soft, commercially pure titanium metal. While the latter machines at 50–90 surface feet per minute, cutting speeds for some of the titanium alloys are of the order of 20–30 surface feet per minute. Tool life is very low indeed. By the increase of nose radius it has been possible to improve tool life. A straight tungsten carbide gave the longest tool wear. Side clearance angle and flank wear and the effect of approach angle are then discussed, and the effect of lubricants on wear.

Thirteen papers were presented at the second session on the machining of materials, which was held under the chairmanship of Mr. L. H. Leedham. The reporter was Mr. C. H. Sparkes, who said : the paper by Dr. D. W. Rudorff (" Machining of Hard Metallic Materials by Electrical Methods ") surveys the various electronic methods for the machining of metallic workpieces. The application of electronic machining is confined to electrically conductive workpieces, but the author suggests that a way may be found to extend it to electrically non-conductive materials by the employment of very high frequency discharges. This method of machining cannot be expected to obtain the results achieved by normal cutting tools, but it has a special field of application in the machining of hardened steels, cemented carbides and similar hard materials.

In his paper, Professor H. Opitz (" The Performance Testing of Machine Tools ") considers that the examination of machine tools according to specifications which have been defined by Schlesinger is insufficient, as these mainly consider the alignments of slideways and bearings when the machine is in its unloaded state. While agreeing that the Schlesinger tests are indispensable, the author proposes that the overall performance of a machine tool should be judged also by its behaviour under static and dynamic load. He also suggests that only those features have to be considered which may have an unfavourable influence on the performance of the machine, the basis of all considerations being the relative movements between tool and workpiece.

Inspection Techniques

Dr. F. H. Rolt was the chairman of the session dealing with inspection techniques, at which seven papers were presented. The reporter, Dr. C. Timms, said : I have read these papers with considerable interest. I propose in part to deal with them collectively and to divide them, where possible, into various subjects, namely, material inspection techniques, dimensional measurement, quality control, and surface finish.

The first paper under material inspection techniques is that by Mr. A. H. Goodger (" Weld Inspection "), in which reference is made to common causes of failure which occur in practice, and the various stages of weld inspection. Methods of non-destructive testing are discussed in great detail and cover visual examination, magnetic testing, penetrants, radiography and ultrasonic examination. He mentions the need for an acceptance code to cover all types of defect and causes of failure in welded construction, but the subject is not one which can be clearly defined in the form of a standard specification.

In a similar way various examples are also mentioned in this section in the paper by Mr. F. Nixon (" Quality in Engineering Manufacture "). He draws attention to many examples, and in particular to the examination of oil coolers and radiators in aircraft engines and the failures which have occurred in practice. He describes in a very characteristic and forthright manner the solutions of these problems. The troubles were due to poor fitting of mating parts, poor soldering techniques, and the use of pre-tinned stock which had become oxidised through long storage. This is but one example out of many which he describes.

Dimensional Measurement

In the paper by Mr. C. O. Taylerson (" The Application of Optics to Engineering Inspection "), the author surveys in considerable detail the background to this subject in relation to work carried out during the first world war and in the inter-war period, and refers to the many examples of instruments which were developed during that time at the National Physical Laboratory. He refers in particular to equipment for measuring the length of slip gauges up to 4in and quotes accuracies of $\pm 0{\cdot}000002$in.

He then deals with angular measurement and refers to the autocollimating telescope and its application to internal measurement, and describes an instrument capable of measuring to an accuracy of $\pm 0{\cdot}00001$in over a range from 0·1in to 6in in diameter. Reference is made to modern types of optical projector covering ranges up to $\times 3000$ for the examination of particles as small as 0·00002in. The author also deals with optical comparators for linear measurement and, at some length, with long-distance metrology, and mentions a " micro " alignment telescope for this purpose which is capable of measuring errors in alignment over 100ft to an accuracy of $\pm 0{\cdot}002$in.

The author refers to interferometric methods of measurement in reference to flatness length and surface finish, and brief mention is made in this respect to the development of the Moire fringe technique and to the use which can be made of it for measurement purposes, and an accuracy of the order of 0·00001in in a length of 30in is stated to be possible.

The paper is mainly concerned with the more basic side of metrological measurements, and only a brief reference is made to continuous measurement. It is in this field that the more recent developments have been made in automatic and continuous measuring techniques, which offer considerable scope for further economy in manufacturing costs by direct inspection control during the various stages of manufacture. This aspect of the subject is discussed in some detail in the paper by Mr. J. Loxham (" The Control of Quality in Engineering Manufacture "), who refers initially to basic methods of measurement and then discusses the basis of measurement in interchangeable manufacture.

An alternative system of measurement is

referred to by Mr. H. J. Elton in his paper (" A Three-Dimensional Tape-Controlled Inspection System "). He describes a system which has found wide use for machine tool control systems, and he has applied it successfully to measurement purposes. It is possible to programme the path of a component so that the surface to be inspected is always in contact with the stylus of the measuring head. Any difference in shape causes a movement of the stylus which is indicated or recorded.

The method has been used with some success for measuring continuously the diameters and positions of holes, and also the finish and lack of circularity of these features. The process differs from other methods of measurement because the author is controlling completely the full dimensional aspect of the various components under examination. The accuracy of repeatability is said to be within 0·0006in, and the overall accuracy of results is within 0·002in. These accuracies have been achieved on an ordinary production milling machine, and the author refers to further measurements which he intends to carry out using a jig borer.

Quality Control and Surface Finish

In the paper by Mr. N. Markback (" Inspection by Sampling ") the word " quality " is used in a restricted sense with particular reference to statistical quality control. This paper deals analytically with the methods for sampling inspection in which the quality of a number of units is judged from the results obtained by inspection of a relatively small part of the total. It refers specifically to methods of single sampling, the economic aspects being discussed in some detail.

In comparison with the development of methods of measuring length and angle, the measurement of surface finish is a comparatively new branch of engineering metrology. As mentioned in the paper by Mr. R. E. Reason (" The Inspection of Surface Finish ") it is concerned with the measurement and analysis of fine structure, of geometrical contours, of sections through surfaces. He mentions the traditional method of specifying surface finish by the specification of process and quality, rough, medium, or fine, denoted often by symbols which are well known to us, and also by inspection by sight and touch.

The main part of the paper is concerned with a new method of approach for the measurement of surface finish, which he describes as the envelope E system, as distinct from the M system, on which the central average unit is based. He shows the development of the envelope system, in which the reference line represents the locus of the centre of the skid (that is, of a circle of defined radius rolling over the surface) moved toward the surface until it comes into contact with the crests.

The author describes the relative geometrical advantages of the E system in relation to the M system. He mentions that the E system has certain advantages in distinguishing between surface roughness and surface waviness by the use of a cylinder of defined radius, and also suggests that, in relation to dimensional accuracy, geometrically the envelope system may have advantages over the M system. He mentions, however, the difficulties which are associated with the numerical determination of the E system by instrumental means. This system, which was developed by Dr. von Weingraber in Germany, has many advantages from the geometrical aspect, but at the present time falls down instrumentally owing to the inability to define the system numerically in suitable form for use in inspection, or by research workers, for that matter.

Instruments, Electronics and Automation

No. I

More than 250 British companies and 100 firms from ten overseas countries are participating in the Instruments, Electronics and Automation Exhibition which opened at Olympia, London, on April 16 and will close on Friday, April 25. A conference is being held in conjunction with the exhibition, the main items in the programme being a series of afternoon lectures on thermonuclear developments (Sceptre 3), instrumentation and high-altitude rockets, instruments in forensic science, computers and numerical automation, instruments in the petro-chemical industry and instrumentation in iron and steel. Some of the exhibits of interest to engineers are described here.

Elliott-Automation Group

FOUR separate stands are being shared by the Elliott-Automation Group which is exhibiting for the first time since the amalgamation, last October, of Elliott Brothers (London), Ltd., and Associated Automation, Ltd., to form Elliott-Automation, Ltd. The members of the Group participating in this exhibition are Elliott Brothers (London), Ltd., Electroflo Meters Company, Ltd., Associated Automation, Ltd., Fisher Governor Company, Ltd., James Gordon and Co., Ltd., Panellit, Ltd., Bristol's Instrument Company, Ltd., Rotometer Manufacturing Company, Ltd., and Santer Controls, Ltd.

The central theme of the main stand (403) is the presentation of process information for control and record, which is one of the basic components of automation. Various examples of instrumentation practice are embodied in a display specially designed to illustrate a number of typical processes. They include, first, the simplest method of presenting process information by means of indicating and recording instruments installed on or near the appropriate plant items. Secondly, there is the more refined method of concentrating all the indicators, recorders and controllers on a control panel, with a degree of manual control in which one part of the process can be adjusted in accordance with readings relating to several other parts. Thirdly, there is the further development of using some kind of continuous automatic data scanning in which each reading is compared in turn with the appropriate preset value and an indication is given to the plant controller when there is any deviation beyond predetermined limits.

Each of these forms of information presentation is represented, graphic panels and control consoles illustrate the instrumentation for an oil tank farm, a refinery, oil- and coal-fired boilers for process steam raising and for electricity generation, a nuclear power plant, and a power station turbo-alternator. In two cases the panel information is scanned by automatic read-out and data-reduction systems ; in a third (an oil-fired boiler console) an automatic computer is shown calculating boiler efficiency at short intervals and printing out results on a strip printer. Another continuous efficiency computer, with automatic high-speed output typewriter, is shown as part of the control system for an oil gasification plant, and another display panel illustrates telemetry applied to remote control for a gas distribution system.

The instrumentation on the various panels and consoles include examples from many of the ranges of equipment available from Elliott Brothers, Panellit, Ltd., James Gordon and Co. Ltd., and Bristol's Instrument Company, Ltd. Of particular interest are examples of electronic (Swartwout Autronic) and pneumatic (Bristol's Metagraphic) control equipment, of Elliott and James Gordon instruments for boiler control and of several new Elliott electrical indicators and recorders, including multi-recorders giving up to six separate records on 3in wide zones of continuous strip charts.

The data read-out and reduction systems shown are by Panellit and include a complete working " 607 " Unit, giving periodic logging with alarm and off-normal indications for from 50 to 200 points, output being typed on preprinted log sheets by a " Compuprinter " high-speed electric typewriter. The control panel and efficiency computer for the oil gasification plant is by Elliott Brothers, again with " Compuprinter " output typewriter.

Another stand (408) is mainly occupied by individual components for automation systems, but one example of a complete equipment, an Elliott Automatic high-speed check-weigher for use with mass-produced consumer goods, is demonstrated. This machine is designed to weigh canned or packaged goods, from a few ounces to several pounds per packet, at rates up to 300 per minute and to an accuracy better than 0·2 per cent ; it can count, channel and/or reject under- or over-weight packets.

Much of the stand, however, is devoted to a display of valves and other components by the Fisher Governor Company, Ltd., and by James Gordon and Co., Ltd. Of special interest is a new Fisher electro-hydraulic operator, specially designed for use with electrical control systems and having a self-contained hydraulic pump and final actuator.

Fairey Aviation Company, Ltd.

A d.c. analogue computing equipment shown by the Fairey Aviation Company, Ltd., 24, Bruton Street, London, W.1., is a recent development based on the company's experience in the designing of aircraft and guided weapons. In these fields, as in process control, it is capable of solving problems in real time.

Full use is made of miniaturisation and printed wiring techniques, and the computer is designed on a unitary basis to fit standard 19in by 6ft racks. A standard range of items is available whereby a computer can be built up to the required size with the maximum of flexibility in the arrangement and utilisation of the equipment.

Briefly, the installation (Fig. 1) consists of a control rack, housing control distribution and checking equipment for operational amplifiers numbering up to 96. For larger computers a number of control racks can be interconnected. The basis of the computer is the computing panel which contains twelve plug-in drift-corrected operational d.c. amplifiers.

Each amplifier has a corresponding plug-in

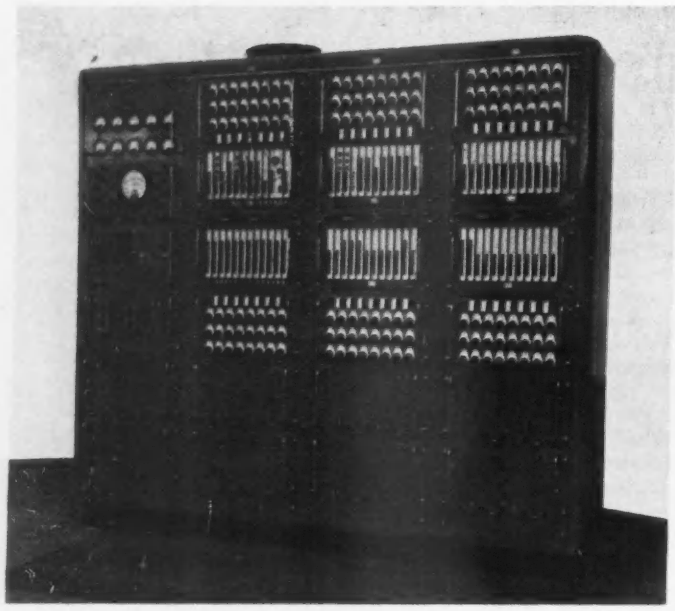


Fig. 1—Direct-current analogue computer with seventy-two operational amplifiers —Fairey

function unit containing feed-back components for summation, integration, integration with "hold," special function generation; there are also non-linear units for providing quadratic functions and clamping facilities (Fig. 2). Other units, such as servo-multipliers and angle resolvers are also available. These special plug-in units are housed in a separate standard servo-function panel containing a servo-amplifier and buffer amplifiers. Solutions can be displayed and recorded on a multi-channel cathode-ray-oscillograph recorder or a quick-response pen recorder.

The company is also showing a photo-electric safety ohmmeter in which the use of a selenium photo-cell as the power source for a resistance bridge eliminates the normal hazards involved in the testing of firing circuits. The need for such an instrument arises from the fact that the checking of explosive components depends upon a measurement of resistance, which implies the application of electrical energy to the circuit. To remove the possibility of accidental ignition, the energy applied during the test must be below the safety margin of the component under any condition of instrument failure, or misuse. In conventional methods this end is achieved by including a current or voltage limiting device with the power source. In the event of a breakdown of this restraint, dangerously high currents can be introduced into the firing circuit, with a consequent risk of ignition. This danger is overcome by the use of a selenium barrier-layer photo-cell, the output of which, under any condition of light saturation or failure, cannot exceed a short-circuit current of 10mA or an open circuit voltage of 0·7V.

The new instrument, designed and developed by the weapon division of the Fairey Aviation Company, Ltd., Heston, Middlesex, utilises a Wheatstone bridge, providing a range of resistance measurement from 0–10K ohms in four switched ranges (0–10 ohms, 0–100 ohms, 0–1K ohms, 0–10K ohms). A "transit" position on the switch is arranged to place a short-circuit across the meter terminals for galvanometer damping. The power source for the bridge is a high-sensitivity infra-red selenium photo-cell, the characteristics of which are modified in manufacture to limit the short-circuit current of the cell at light saturation, and yet maintain a high-sensitivity at low illumination intensities. Null indication is provided by a sensitive centre-zero galvanometer, having pole pieces shaped for off-balance insensitivity. To achieve a high accuracy and stability, ±0·1 per cent wire-wound resistors, cast in an "Araldite" block, are used for the bridge ratio arms, and a wire-wound cam-corrected potentiometer of ±0·1 per cent linearity for the variable element. To compensate for the ±5 per cent overall resistance tolerance of this potentiometer, a 5 ohm variable wire-wound resistance is included in the fixed ratio arm. This is accurately adjusted on initial assembly and locked.

The instrument consists of an inner sealed case, enclosing the bridge components, contained in an outer protective cover (Fig. 3) measuring 11in by 7in by 4in overall. The galvanometer and photo-cell are attached to the under-side of a "Perspex" plate which forms the lid of the inner case, and is hermetically sealed to it by a "Neoprene" washer. Cut-outs in the outer cover provide viewing access to the range and scale information, meter and photo-cell. To prevent accidental earthing of a test circuit by the instrument, the outer case is flame sprayed with a tough durable coating of "Nylon." A connection to the instrument screen is provided for use if required. The range and scale drums are mounted adjacently and viewed through a single aperture. Control of the range switch and variable resistance is by 3½in diameter knobs. Sealing of spindles, fixing screws, &c., is achieved by means of bonded seals.

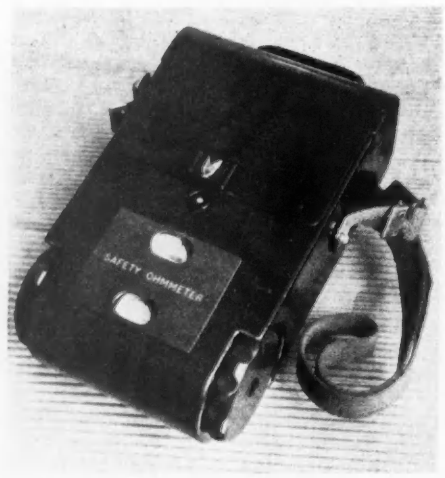


Fig. 3—Photo-electric safety ohmmeter in which the use of a selenium photocell as the power source for a resistance bridge reduces the risks involved in the testing of firing circuits—Fairey

The fundamental bridge accuracy (determined by component tolerances) is stated to be of the order of ±0·3 per cent. The measurement accuracy, however, is dependent upon the sensitivity of measurement and the scale reading accuracy. At low illumination intensities (i.e. below 50ft-candles), and under the load conditions presented by the bridge at any setting, the photo-cell is essentially a constant current generator. The current output, and therefore the sensitivity of the bridge, is directly proportional to the intensity of the light incident on the photo-cell. The illumination intensities required to produce a detectable galvanometer current for different range and scale settings are shown in Table I. They are based on a ±10 per cent incremental change of the vari-

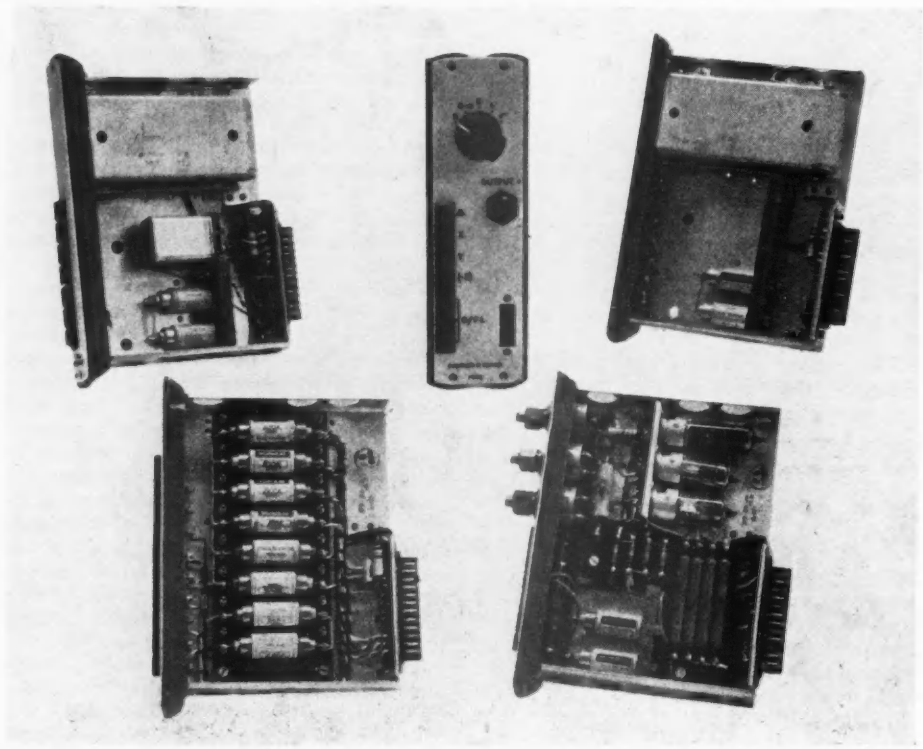


Fig. 2—Function units of analogue computer. (Top, left to right) integrator with holds, quadratic function unit, integrator. (Bottom, left to right) summation unit, clamping unit—Fairey

able element and are an indication of the measurement sensitivity of the instrument.

TABLE I—*Illumination Intensities Required to Produce a Detectable Galvanometer Current for a ±10 per cent Incremental Change in Resistance Setting.*

Range	Percentage scale reading (ft. candles)			
	5 per cent	10 per cent	50 per cent	100 per cent
0–10 ohms ...	9	5·5	3	2·7
0–100 ohms ...	2	1·3	0·8	0·7
0–1K ohms ...	2·5	2	1·7	11·6
0–10K ohms ...	13	12	12	12

Using normal bridge balancing techniques, an improvement of at least 2 : 1 in bridge setting accuracy can readily be achieved, since the figures quoted for measurement sensitivity relate to a detectable galvanometer deflection. Thus the intensities given in Table I are sufficient to provide a measurement accuracy of approximately ±5 per cent. For higher accuracies, the illumination intensities should be increased proportionally. High-scale reading accuracy is ensured by the use of a precision cam-corrected potentiometer, wired as a variable resistance, and an accurately graduated scale drum. This has an effective scale length of 6·5in for 100 divisions. The resistance angle of the potentiometer is held in manufacture to 300 deg. +0 deg.—0·25 deg., and the linearity to ±0·1 per cent. Backlash is eliminated by fixing the scale drum directly to the driving shaft of the potentiometer.

THE GENERAL ELECTRIC COMPANY, LTD.

An r.f. reflectometer for testing wide-band waveguide and coaxial line components, a d.c. transistor inverter, and a liquid gauging instrument incorporating transistors are among the new devices shown by The General Electric Company, Ltd., Magnet House, Kingsway, London, W.C.2.

The r.f. reflectometer is designed to reduce the time needed to test wide-band waveguide and coaxial line components, so that, effectively, the work of days can now be compressed into a few hours. The reflectometer displays the magnitude of the reflection coefficient of a microwave device on a cathode ray oscilloscope, and can also be used to show the transmission coefficient. The three essential components of the instrument are a microwave generator with power supplies, electronic frequency scanning supply and a regulating feedback circuit ; an r.f. circuit comprising level-setting attenuator, wavemeter, and two directional couplers each with a crystal detector and matched load on the coupled arm ; and an oscilloscope, with power supplies, amplifiers and display circuits. The complete equipment (Fig. 5) is at present available in waveguide-sixteen for X-band (7500 to 11,000 Mc/s), and in coaxial line for S-band (2000 to 3200 or 2400 to 4000 Mc/s).

The d.c. transistor inverter is an equipment which was designed for Vickers-Armstrongs (Aircraft), Ltd., to operate aircraft fluorescent lighting from completely static equipment, but is applicable to most forms of transport. It is stated to be more economical and efficient, as well as quieter, than the vibrator or rotary convertor which has previously been necessary.

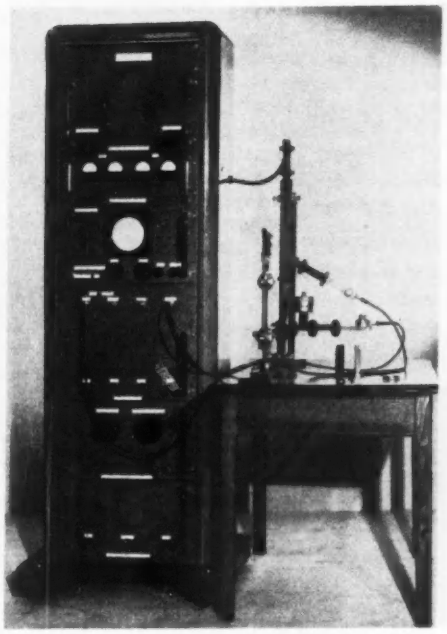


Fig. 5—Radio-frequency reflectometer designed to reduce substantially the time needed for testing wide-band waveguide and coaxial line components—G.E.C.

With a rating of 20W, the transistor inverter operates on 24V d.c. supplies. The dimensions of this compact unit are only 7in by 2½in by 1¼in, and the weight is 1¼ lb.

The transistorised level-measuring unit for liquid oxygen was developed specifically for use with aircraft liquid oxygen containers, but it is equally suitable for measuring the level of any liquid. The liquid oxygen convertors manufactured by the British Oxygen Company contain a capacitative sensing element which completes a capacitance bridge circuit in the gauging unit. For use in aircraft, the bridge is fed by a self-contained oscillator working on 28V d.c. supplies, the error signal from the bridge being amplified for electrical instrument readings. The indicator shows the quantity of liquid oxygen and gives warning of any failure to the supply or the gauging system. Cast in synthetic resin to ensure rigidity and freedom from moisture, the unit employs printed circuits and G.E.C. transistors. The main particulars are : power supply, 28V nominal (25V to 29V permissible) ; power consumption, less than 1·5W ; size of gauging unit, 3⅜in by 1¾in by 2in; weight of gauging unit, less than 1 lb ; size of indicator, 2¼in diameter S.A.E. standard case, 2½in long.

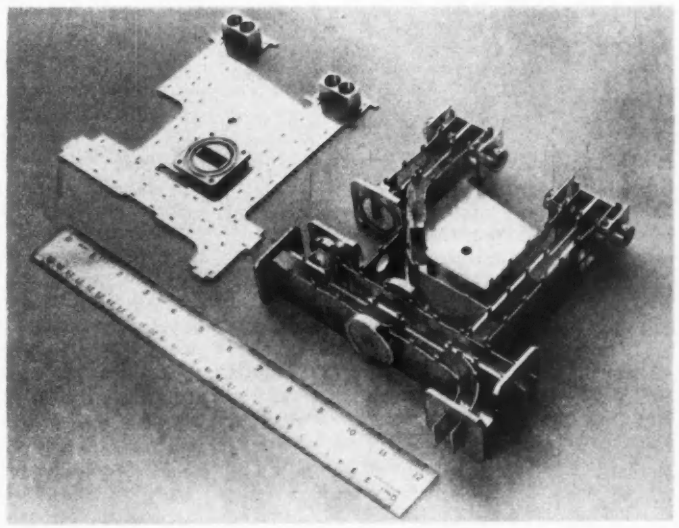


Fig. 4—Partly assembled dip-brazed aluminium waveguide. This technique has been developed to reduce weight and allow greater flexibility in design of such components—G.E.C.

The display also includes a fabricated dip-brazed aluminium waveguide which exemplifies a technique developed by the G.E.C. for the ready manufacture of almost any shape of waveguide components, providing much lighter and more flexible designs (Fig. 4). The process involves the use of specially coated aluminium sheet which is punched and assembled by an interlocking tag and slot construction, thus dispensing with the necessity of assembling and brazing jigs. The whole unit can, therefore, be brought up to temperature quickly and uniformly by means of salt-bath brazing, eliminating the distortion experienced with torch brazing methods. In addition, the salt dip-braze produces cleaner and more uniform joints, and on X-band waveguides, tolerances can be maintained to within 0·002in. With this technique, it has been possible to replace a complex system of aluminium die-cast waveguide components for an airborne radar transmitter receiver, the reduction in weight being from 8 lb to less than 1 lb.

The company is also showing a new travelling-wave tube (T.W.S.1) which is intended for use in the 1500 to 3000 Mc/s frequency range. This new c.w. power amplifier is convection-cooled and, since no pumps or other moving parts are employed, the valve is very suitable for use in unattended microwave link equipment.

It is stated that an output of 38W can be obtained with a power gain of 26 dB, and as the gain is a function of the helix voltage the valve is recommended for most broadband amplifier and variable attenuator requirements.

(*To be continued*)

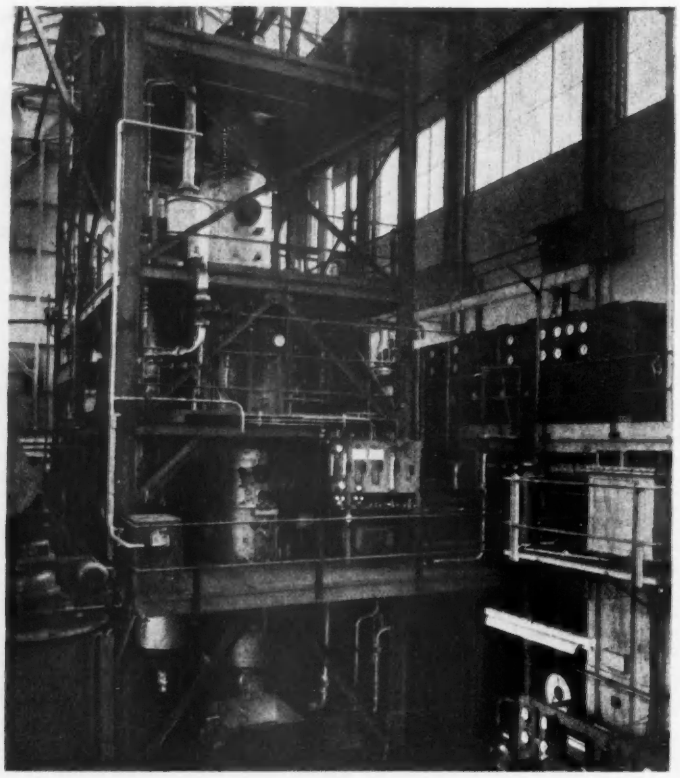
British Standards Institution

All British Standard Specifications can be obtained from the Sales Department of the Institution at 2, Park Street, London, W.1.

GENERAL PURPOSE ACME SCREW THREADS

No. 1104 : 1957. Price 7s. 6d. Since the publication of the 1943 edition of " General Purpose Acme Screw Threads " the need has been established for a range of threads suitable for different classes of work. Hence the issue of this revised edition, which was prepared under the authority of B.S.I.'s Mechanical Engineering Industry Standards Committee. It replaces the 1943 edition, which was withdrawn when the American Standards Association began the revision of its standard, on which B.S. 1104 : 1943 was based. The revision is in accordance with its American counterpart (A.S.A. B1.5 : 1952) as regards diameters, pitches and limits and tolerances for the three classes of thread designated " 2G," " 3G " and " 4G." An additional class, " 5G," has, however, been provided in the British Standard. A thorough review of British industrial usage has compelled a departure from the U.S. Standard Series of diameter/pitch combination in respect of ¼in, ⅝in, 1in, 1¼in and 1½in diameters. Tables of effective diameter tolerances for an extended range of diameter/pitch combinations are provided in the standard, and from these and other related tables the limiting dimensions for any special diameter/pitch combination of single or multi-start Acme form thread can be calculated. The general purpose threads specified in the standard have clearance on diameters for free lateral movement to accommodate possible errors in alignment of the axis of the fixed nut and that of the screw which engages with it. They are not intended for applications where centralising is necessary ; such threads may form the subject of a separate standard. The standard recommends that the threads be gauged according to British principles and practice.

Midlands Gas Research Station



The new Midlands Research Station of the Gas Council was officially opened at Solihull, Warwickshire, on Tuesday, April 1, by Sir Cyril Hinshelwood. Work at this station is being largely directed to the investigation of processes of the complete gasification of low-grade coals, hitherto thought unsuitable for gas making. In the pressure gasification processes which are mainly being investigated and developed, gas is made and purified inside vessels at pressures up to several hundred pounds per square inch. For one such investigation the experimental slagging gasifier, to be seen on the right, has been designed and erected in the laboratories. This equipment operates at a very high temperature which requires the ash to be withdrawn in the form of a molten slag. In this article attention is drawn to some of the work in hand at the station, which will undoubtedly lead to developments of the utmost importance to the gas industry of this country.

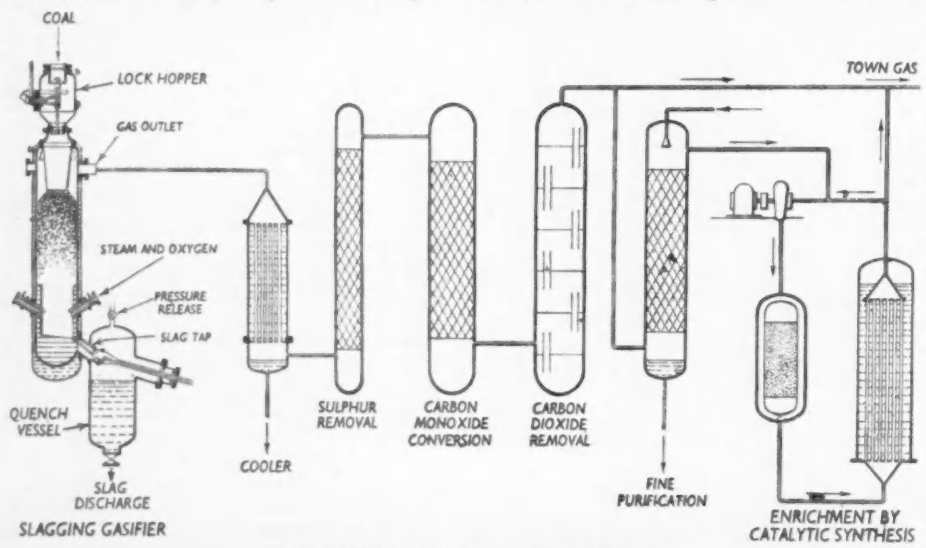
THE new research station of the Gas Council at Solihull, Warwickshire, has been officially opened, and its work is being mainly concentrated on the investigation into processes for the complete gasification of low-grade coals with a number of pressure gasification processes. This particular line of research has of recent years become increasingly important owing to the rapidly dwindling supplies of coking coals with a low ash content, as well as the national interest in reducing overall consumption of coal.

Initially the new station, which covers an area of some 4 acres, consists of a pilot plant building, a workshop and stores, and a coal preparation plant house. A proposed administration and laboratory block is to be built later, and for the present temporary laboratory accommodation is provided in other buildings. The workshop building consists of a two-storey office block with a single-storey shop, 247ft long by 50ft wide, at the rear. The pilot plant building, which is 254ft long by 42ft wide, has been constructed with a height of 51ft to the eaves in order to provide sufficient height for the construction of tall pilot plants. An open yard at the side of the building provides space for fuel storage and the erection of machinery and pilot plants suitable for operation in the open. In the coal preparation building (52ft long by 38ft wide) there are installed two coal pulverising and classifying plants, elevators, hoppers and coal drying rooms.

The pressure gasification processes under investigation are of particular interest, and a number of reasons are put forward for adopting high-pressure techniques. Pressure facilitates the rapid gasification of small coal and enables plant units to have the high capacity required for super-stations. In output, individual units will compare with what are now regarded as relatively large-sized gasworks. When, per ton of coal, gas yield is three times greater than normal, it tends to be of lower calorific value. One of the most important findings at Solihull has been that the use of pressure allows this tendency to be corrected by reacting hydrogen with the coal—a pressure reaction. The indication for the future is that, due to this hydrogenation process, the calorific value of town gas will be increased above what is now distributed. It is further pointed out that the use of pressure simplifies the attainment of the desired high purity in the gas and enables gas of the same composition to be produced from quite different raw materials. In consequence, the introduction of pressure processes will open the way to a greater uniformity of gas supplies in different parts of the country. By-products in pressure processes are of high quality and the intention is that the new processes will have no objectionable effluents, either gaseous or liquid. Distribution costs less when the gas is under pressure ; furthermore, compression costs are also avoided when, at times of reduced demand, surplus gas is used for making chemicals and liquid fuels.

As a result of research and experiment it was decided that the most suitable pressure process of gasification which could be adopted in large gas stations would use powdered coal, and by introducing what are called " fluidised " techniques the maximum control would be obtained over the chemical reactions. In these techniques powdered coal will be treated under pressure, first with hydrogen to produce by-products and the rich constituent of the final gas. The solid residue from this hydrogenation will then be gasified to completion in oxygen and steam. It is thought that such a two-stage process can be developed to meet all the requirements and, at the Research Station, a pilot scale plant is being erected. Work is, however, not confined to this one process as it is considered of the utmost importance to introduce high-pressure techniques into commercial operation as soon as possible. The experience of day-to-day operation obtained thereby will be of the greatest value for further developments, and will help to train personnel in the new techniques. Accordingly, in addition to experiments on the fluidised process, work is also proceeding on the best of available pressure processes so as to make them suitable for immediate installation.

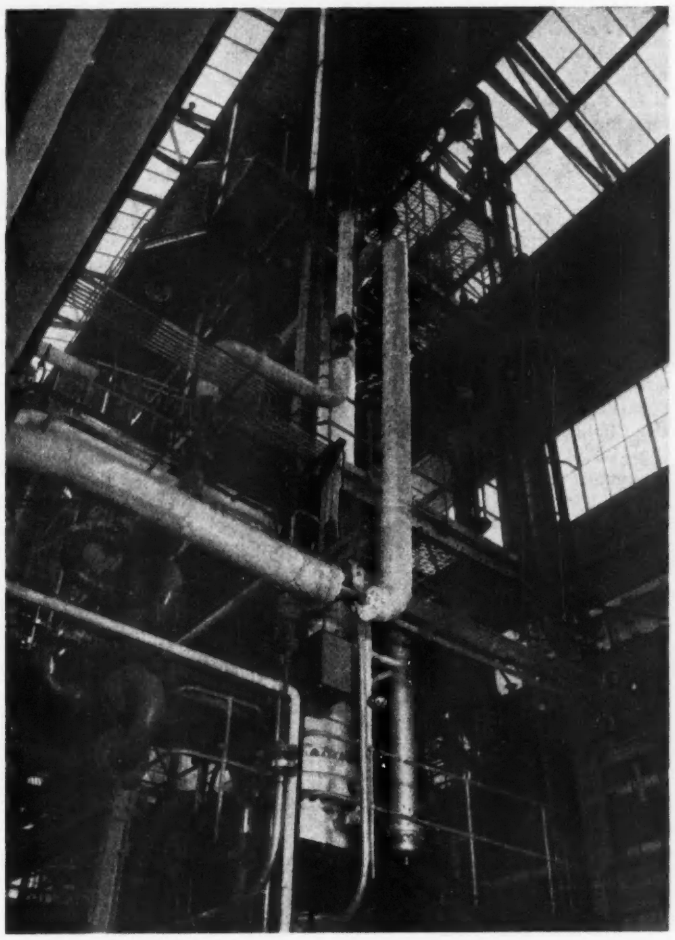
It is important for the overall economy of gas supply to use processes to produce gas for peak loads. Such processes must involve only a minimum of plant, since it is standing idle for most of the time, and these peak load plants may well use oil rather than coal, since



Process diagram of pilot slagging gasifier

oil is more readily gasified and less plant is required for the operation. For this reason auxiliary pressure processes for gasifying oil are also being developed, making use of the advantage of pressure to obtain gas of identical composition and purity from both raw materials. These auxiliary oil processes will have a secondary function in that the plant they require is relatively cheap and small units can be erected economically. They can be installed immediately in isolated localities, without waiting for grid connections, so that the benefit from the production of high-quality gas by pressure processes is obtained as early as possible.

Probably one of the most interesting pilot plants under investigation in the laboratory is the slagging gasifier, on which work is being carried out jointly with the Ministry of Power. This plant operates at a very high temperature, which requires the ash to be withdrawn as a slag. The high temperature is stated to result in increased efficiency, high unit outputs, a saving of process steam, and a reduction in the cost of by-product recovery. With these advantages it becomes more of a proposition to enrich the gas with methane produced catalytically as an alternative to oil and, with catalytic synthesis, the process becomes an all-coal process. Catalytic methane synthesis has been brought to the stage of commercial application, but the slagging gasifier itself is still under test. The first problem with the gasifier was to find a method of handling the molten slag inside the pressure system. This has been done and the next step is to adapt the gasifier to deal with the various types of British coal; in the experiments made so far, coke has been used as the fuel. The installation of a prototype slagging unit on the commercial scale is now being discussed.



Pilot hydrogenation plant for the pressure gasification of heavy and crude oils

The gas produced from a slagging gasifier is high in carbon monoxide and of lower calorific value than town gas. In the process developed these points are remedied by converting the carbon monoxide catalytically, partly to hydrogen and partly to methane. The conversion to hydrogen is already an industrial process, while the conversion to methane has been developed through the pilot plant scale. As can be seen in the diagram, gas recirculation is used to control the temperature of the catalyst.

The pilot slagging gasifier consists of a 3ft internal diameter water-jacketed vessel in which the fuel is gasified under pressure in a mixture of steam and oxygen. This mixture enters through four tuyeres round the hearth, and the ratio of steam and oxygen, which varies from 1·0 to 1·5 by volume, is chosen so that the temperatures developed in the fuel bed are sufficiently high to fuse the ash of the fuel, which runs down and collects in the hearth. Periodically this slag is allowed to stream from the gasifier into a vessel containing water, where quenching fragments it into a granular material. In the experiments carried out so far, coke has been used as fuel with limestone added to flux the ash.

The gasifier is being operated to produce 1,000,000 cubic feet of gas per day, the maximum possible with the steam and oxygen supplies available. It is considered that with increased supplies much higher outputs could be reached and, with slagging temperatures, unit outputs of 30,000,000 cubic feet should be obtainable in commercial plant.

The coal fed to the top of the gasifier must be above ¼in in size but, with slagging, there is the interesting possibility of using a proportion of coal dust, since this can be injected with the steam and oxygen through the tuyeres. Other features of this type of gasifier are its high thermal efficiency, the high percentage of steam decomposed, and the small amount of liquor produced. The next stage of this investigation is to simplify the slag quenching system according to the experience obtained, and then equip the gasifier to operate on coal. This requires a stirrer in the top of the fuel bed to break up agglomerations which form as the coal is being raised to reaction temperature.

A pilot Lurgi design gasifier installed has a 2ft diameter chamber and has been used to make a detailed survey of the reactions and temperatures inside the fuel bed. Like the slagging gasifier, this plant gasifies coal under pressure in a mixture of oxygen and steam, but temperatures in the fuel bed are kept below the clinkering temperature of the ash by increasing the proportion of steam, viz., to 8–10 volumes per volume of oxygen; the ash can then be extracted by a mechanical grate. An excess of steam escapes decomposition and produces a large amount of liquor, and the overall efficiency is reduced in consequence. The Lurgi gasifier, however, represents an established system of gasification which, under prevailing conditions, can be made attractive by the addition of a stage of oil hydrogenation for the enrichment of the gas. The pilot plant is to be used for tests aimed at reducing steam consumption.

Both the Lurgi and the slagging gasifiers need a proportion of the coal used to be above ¼in size, and pilot scale development has started on a powdered coal process which will deal with any size of coal down to dust. It incorporates the hydrogenation of coal itself and, with an overall thermal efficiency of 75 per cent, is thought to be the best method of both by-product recovery and gas enrichment. It is considered that the experience obtained on the slagging gasifier will allow the design of a powdered fuel gasifier suitable for the residue from the fluid hydrogenation.

In this plant the coal is hydrogenated in a 30ft high, 1ft internal diameter, pressure vessel into the top of which is fed coal crushed to pass a 35 mesh sieve. In about fifteen minutes this coal descends through the bed, reacting with the hydrogen gas, which is passing upwards and maintaining the coal in the fluidised state. The reaction produces gaseous hydrocarbons and by-products. Unlike oil, coal does not hydrogenate to completion and a powder carbon residue remains. It is intended that this residue will be gasified in steam and oxygen to produce the hydrogen for hydrogenation.

A process for the pressure gasification of oil is based on the Gas Council's process of oil hydrogenation and has two versions. One process uses distillate oils which can be vaporised and purified before entering the reaction vessel. The other process uses heavy fuel oils and crude oils which must be atomised. In the process reaction temperatures are controlled by a fluidised bed of carbon.

These oil processes differ from those for coal in not requiring oxygen, and this is the principal reason for plant costs being lower. They operate at a thermal efficiency of 80 per cent and are also characterised by high yields of pure benzene as a by-product. A large pilot unit for crude and heavy oil erected at Solihull is shown in one of our illustrations, while a prototype commercial unit is to be installed at Manchester. The distillate oil version, which is nearer normal commercial application, is already interesting a number of Gas Boards.

The pilot oil hydrogenator at Solihull has a capacity of 1,000,000 cubic feet per day and in it the crude and heavy oils are sprayed into the base of a fluidised bed of powdered coke which has the hydrogen streaming through it. The reaction which occurs generates sufficient heat to maintain the temperature at 700–800 deg. Cent. The working pressure is 20–30 atmospheres. The hydrogen required in this plant is obtained from part of the rich gas made in the hydrogenator in the following sequence of plant: a Benfield plant for the removal of sulphur compounds; a catalytic reformer, in which gaseous hydrocarbons interact with steam to produce the hydrogen; a converter for carbon monoxide and, finally, a water wash to remove carbon dioxide.

A laboratory in the pilot plant building is concerned with utilisation research, including high velocity jet burners, the recuperation of heat by plate heat exchangers, and the investigation of flame traps as barriers to detonation.

Report on Practical Training

THE Institution of Mechanical Engineers has issued a report on practical training. It has been prepared by a committee appointed by the council in November, 1956, to review the whole subject of the Institution's practical training requirements. In that task, the committee was asked to take into account the views of the Institution's education and membership committees. That request was made because the membership committee sometimes finds difficulty in interpreting satisfactorily the Institution's by-law requiring anyone applying for corporate membership to produce evidence of "sufficient practical experience." The interpretation at present given to that requirement is "a period of not less than eighteen months in mechanical engineering workshops in industry." But this, it has been suggested, does not wholly accord with present needs and, consequently, it is the matter which has had first place in the committee's deliberations.

The report, it is emphasised, is primarily concerned with those who are taking, or who intend to take, a full-time academic course in mechanical engineering at a university or technical college. The report starts off by expressing the committee's conviction that practical training in some form is essential for all those who aspire to become chartered mechanical engineers, whatever form of academic course is being followed. It is felt that there is a strong case for practical training and academic studies being so integrated that the learner can fully comprehend the significance of each. Those existing schemes which impart education in one block and practical training in another do not appear to provide the best combination of theory and practice.

The report goes on to describe the purpose of practical training as being to relate theoretical knowledge to actual practice. First-hand contact with some of the everyday problems of mechanical engineering not only increases the learner's all-round knowledge, but also builds up his confidence and stimulates his interest. In particular, the report urges, practical training should provide the learner with direct knowledge of: the potentialities and limitations of basic workshop processes, the abilities and skills required by personnel employed in these processes, the important part played by experience, the importance of co-operation and of good human relations in promoting efficiency and well-being on the shop floor and in the office, some of the principles of engineering organisation and administration, and various general aspects of work undertaken by professional engineers. These requirements, it is pointed out, are in part technological and in part general. Some of the technological experience may best be acquired elsewhere than on the shop floor, since this is unlikely to provide all the training facilities and instruction required. General experience, involving much that cannot be directly taught, can be gained only through direct contact with the personnel of an engineering works or similar establishment. Although many mechanical engineers, as their careers develop, change from one activity to another, the committee's opinion is that practical training should, at any rate in its later phases, bear some relationship to the kind of work which the young engineer plans to do during the years immediately following his training.

Fundamental Proposals

The foregoing considerations have led the committee to recommend that practical training should be divided into two stages, as follows:

Basic Training.—During this phase of training essential facts can be taught and certain basic experience acquired.

Secondary Training.—During this phase broader knowledge is acquired, insight is obtained into some of the workings of industry and human contacts are made at all levels. In the later part of this phase, training is related to the particular activity in which the individual will be employed when he has finished his training.

The committee stresses the general principle that theoretical and practical training studies should be closely co-ordinated to ensure that the total training period is treated as far as possible as an integrated whole. The order in which the practical and theoretical elements are arranged is not uniform throughout the country. Some universities recommend candidates to proceed direct from school to university, deferring practical training until university studies for a first degree have been completed, though one or more vacation periods may be spent in industry. Others favour a sandwich course which includes six to twelve months of practical training between school and university, the balance being obtained after graduating. Still other colleges, especially those associated with the National Council for Technological Awards of Diplomas in Technology, prefer "works-based" sandwich schemes in which alternate periods of six months each are spent in industry and at college over a period of four or five years. All these schemes have certain merits. The particular scheme to be followed may depend upon personal circumstances and upon the career to be followed. The committee considers that in certain cases some vacation periods may be devoted to part of the basic training programme, though it is appreciated that such periods may often be more usefully spent in other ways in pursuit of general or liberal experience.

Consideration of argument and counter-argument, the report continues, has resulted in the committee basing its detailed recommendations on the following principles:

(i) Practical training must be firmly based on proper instruction coupled with actual experience of the processes being learned: planned "learning by doing" under skilled tuition, as opposed to vague experience based on chance. (ii) Practical training schemes must be broadly based and yet they should also in their later stages take into account the kind of work which the individual is to do when his training ends. (iii) Opportunities must be provided for individuals who have not yet decided in which activity they wish to work after their apprenticeship, to gain experience in various kinds of work during the early months of secondary training.

In submitting (in an appendix to the report) detailed proposals for basic training, the committee adheres to a fundamental principle that it should be based on proper teaching by adequately qualified instructors. There must be instruction in the principles underlying the tools or processes being dealt with, followed by the learner experiencing for himself the workings of the process or machine. The committee says it has been impressed with the criticism that at present the graduate apprentice sometimes spends time on repetitive machine work, in observing machines and in other wasteful ways.

Instruction, the committee believes, is best carried out in a training workshop, separate in organisation from the production workshops although under ideal conditions forming part of them. The practice of using a special training workshop is already well established in many larger firms and the committee expects that the practice will spread. There are advantages in co-operation between several firms in a given district in the setting up of a training workshop in the factory of one of the firms, if each independently is not able to organise its own training school. It is also hoped that some technical colleges will provide suitable workshops and may eventually be able to offer facilities for basic training to those students who may not be able to make suitable arrangements with industry. Obviously a co-operative scheme between the college and local industry may well be found to be a suitable arrangement. The committee feels that, once the principle of the desirability of basic training being given at an early age has been accepted, arrangements can be worked out to suit local conditions. The capital cost of the equipment for the kind of practical training envisaged is not unduly large. But, the report adds, bearing in mind that basic training may have been carried out in a technical college, that is away from a factory atmosphere, it is possible that many young men may still have little first-hand experience of the engineering industry. Even those who have done their basic training in an industrial workshop will have had little or no direct experience of the shop floor. It is, therefore, essential for all, irrespective of the activity they will be engaged in, to spend the early secondary training in engineering workshops and offices.

It is important, the report stresses, that those who have not yet decided upon their future careers should be given an opportunity to do so during the early period of secondary training. Until a decision about future career has been made secondary training should not be specialised, but when a man's mind has been made up his chosen career ought to be taken into account in planning the remainder of his secondary training. Recommendations as to the general lines of secondary training are set out in another appendix. The ultimate spheres of activity in which a man may be employed after training are listed as: manufacture, design and development, commercial departments, operation and maintenance, research.

Conclusion

The report ends by commenting that the practical training of mechanical engineers is a subject on which many differing opinions exist. The committee has endeavoured to set out what it conceives to be sound principles, and its report is offered for general comment by all those concerned with what is a fundamental part of the process of becoming a professional mechanical engineer. It is pointed out that mechanical engineers are employed in a wide variety of industries and other vital fields, and in various functions within these activities. For this reason training programmes must themselves vary, and there is no rigid pattern of training which can be universally applied. The science of mechanical engineering is in any case a continuously developing one, and its applications are always increasing. It follows that there is room for experiment and new ideas in working out schemes of practical training. The committee's desire is to encourage a dynamic attitude to the subject.

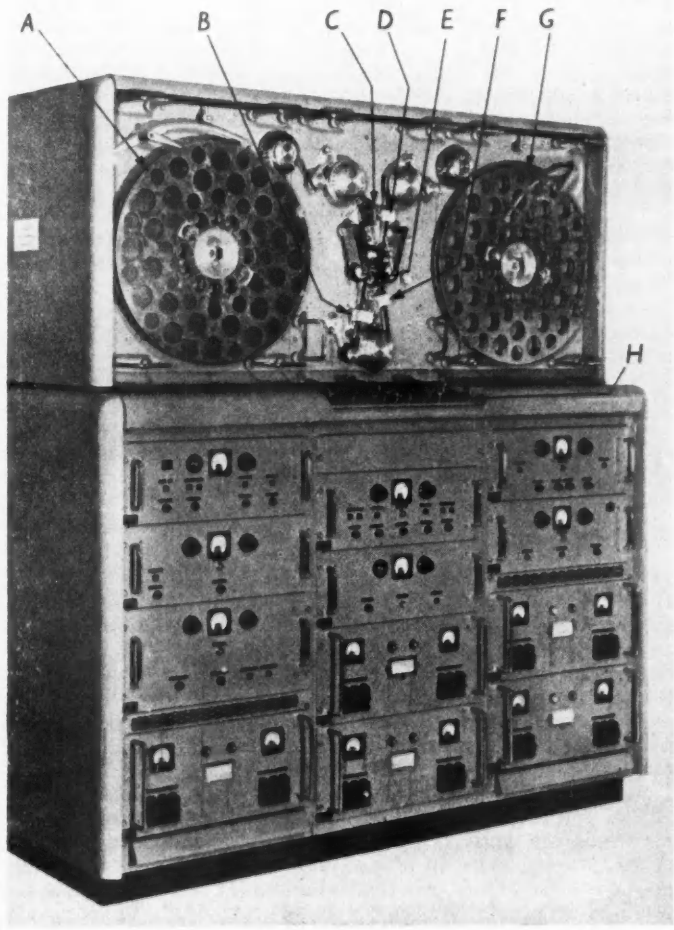
Vision Electronic Recording Apparatus

THE Vision Electronic Recording Apparatus known as "VERA" (illustrated here) has been designed and developed in the research department of the B.B.C. to record the vision and sound signals of television programmes for subsequent reproduction at any time after the recording has been made. The channels which are to be put into service will consist of two machines, similar to the one illustrated, which can be controlled from a central control desk. The machine uses ½in magnetic tape, and a reel (20½in diameter) such as those shown will carry fifteen minutes of programme. Continuous recording is possible by the use of two machines and the control desk. The tape speed employed in the present model is 200in per second and the magnetic tape used may be a normal thin-base sound recording tape of good quality.

"VERA" uses a three-track system of recording, two of the tracks being devoted to the storing of the video signal and one to the storing of the sound signal. Separate recording and reproducing head-stacks are employed, each stack containing three identical heads separated from each other by copper screens and aligned to the accuracy required in the manufacturing process. Continuous monitoring of the recorded signal during the process of recording may be carried out.

In the tape transport system embodied in the machine most of the power required to drive the tape is supplied by the spooling motors, which are arranged to move the tape past the heads at a speed just below the chosen recording speed of 200in per second and close to the constant tension required, even when the drive motor is not engaged. This result is obtained by varying the power fed to the spooling motors in accordance with (*a*) their torque/speed characteristic, and (*b*) the amount of tape on the reels at any particular moment, the latter determining the speed of rotation required of the reels. When the drive is engaged the drive motor is, therefore, required to supply only a limited amount of power to bring the tape speed up to 200in per second. The drive is engaged by lowering two rubber idlers on to a common capstan so that there is formed a loop of tape which is largely isolated from transient effects in the reels by the idlers and other mechanical filtering elements. Inside this loop lie the recording and reproducing head-stacks, the magnetic parts of which incorporate ferrite materials. Each head is stated to have an effective life of some 100 hours. The erasing head is placed at a convenient point which lies outside the loop and precedes the recording head. A "Velodyne" system of speed control and correction of the driving capstan is employed. During recording periods the servo driving motor is made synchronous with the mains frequency, whilst on reproduction the output of the machine is frame-synchronised to station synchronisation signals. The machine is fitted with the usual facilities for braking and for spooling the tape backwards or forwards at a variable speed when the drive system is not engaged.

For storing the video signal the two video tracks are associated, on the recording side, with a band-splitting system in which the video signal is divided into two frequency bands of approximately 0 to 100 kc/s and 100 kc/s to 3 Mc/s. The 0 to 100 kc/s video band is made to frequency modulate a carrier and this frequency-modulated carrier is recorded on one track. The low-frequency content of the video signal is thereby transferred to a frequency band corresponding to shorter wavelengths so that both the low-frequency and the long-wavelength difficulties inherent in the conventional magnetic recording system are avoided. In addition, the amplitude-limiting facilities normally associated with the reception of frequency-modulated signals may be incorporated in the reproducing chain to eliminate undesired amplitude fluctuations and overcome almost all "drop-out" difficulties, even when employing thin-base sound recording tape not specifically manufactured for video or instrumentation purposes. The higher vision band, from 100 kc/s upwards, is recorded simultaneously on the second video track in a conventional manner.



A—Feed spool. *B*—Recording head. *C*—Release head.
D—Cue head. *E*—Capstan. *F*—Reproducing head.
G—Take-up spool. *H*—Control panel.

Vision Electronic Recording Apparatus ("VERA") developed and made by the B.B.C. It uses commercial quality magnetic recording tape ½in wide, running at 200in per second, and carrying three recording tracks. One track, using frequency modulation, is for sound. For the video signals the lower frequency band, frequency-modulated, is on a second track, and the higher frequencies on a third track

On reproduction the output from the frequency-modulated video track is limited, demodulated, and added to the output from the higher frequency track to reform the composite television waveform. Before transmission to line the synchronisation information, including line and frame synchronising signals and suppression periods, is extracted, reconstituted and added back into the video signal. It is, of course, obvious that the higher frequency video band, which employs a conventional recording/reproducing system, will be subject to the same unwanted amplitude-modulation which is being eliminated by the frequency-modulation system of the lower frequency video band. It is, however, an important finding that in practice this does not appear of major importance, for as long as the synchronisation signals and the main brightness structure of the picture, represented by the 0 to 100 kc/s band of the video signal, are maintained intact, reasonable variations in the higher frequency band do not noticeably degrade the subjective result.

All the low-frequency and long-wavelength difficulties which, in the case of the lower video frequency, are overcome by the use of the carrier system, will also be manifest in the sound channel if a conventional recording of the sound signal is attempted under the higher tape speed conditions dictated by the video signal requirements. These difficulties are overcome by employing an identical technique to that used to store the lower video frequencies. Accordingly, the sound signal is, before recording, made to frequency-modulate another carrier which is recorded on the third track. On reproduction the carrier is limited and demodulated to provide a sound signal of high fidelity exactly synchronous in time with the video information reproduced from the other two tracks.

As in other forms of picture or sound recording a requirement will arise in the use of magnetic vision recorders for the editing of programme previously recorded. Simple editing, in the form of replaying extracts from a previously recorded programme, may be achieved by starting the machine at any predetermined point in the recording. This facility is available because the machine is equipped with the usual facilities for spooling the tape backwards and forwards to find a desired point in the recording. The method may be extended, as in magnetic sound-recording practice, by cutting and joining extracts from various recordings or different parts of the same recording. Individual frames cannot, however, be examined in a "gate," as in optical film editing, for the tape must be reproduced at the correct speed before a picture can be reproduced on a monitor. A cueing arrangement for the "marking" of editing points has, therefore, been provided. For this purpose there is provided an extra cueing head, lying outside the isolated tape loop, which is fed through a separate recording amplifier from a 30 kc/s oscillator. When the tape is being normally reproduced and the observer wishes to mark some particular point for subsequent cutting or starting he presses a "Cue" key on the control panel of the machine which causes a 30 kc/s burst of signal to be recorded on the sound track of the tape. At this frequency it will not appear in subsequent normal reproduction, since it lies well below the frequency-modulated carrier signals which carry the sound programme, and any interference effects it might otherwise have will be removed by the limiting process which precedes detection of the television sound signal. When the tape is being slowly moved past the reproducing head, using the spooling speed control, at a fraction of the normal speed, the cue signal will produce an audible note in the loudspeaker or headphone system so that the point previously marked is found.

The cutting and joining of tapes is accurately and quickly carried out by the use of a splicing device provided and the resultant join provides no visible disturbance in the picture.

Industrial and Labour Notes

Railway Wages

As we go to press, leaders of the three railway unions are discussing their wage demands with Sir Brian Robertson, chairman of the British Transport Commission. This meeting follows the findings of the Railway Staff National Tribunal, which were announced at the end of last week. The three unions each submitted a claim last autumn on behalf of their members employed on British Railways, the National Union of Railwaymen asking for a "substantial" but unspecified increase, the Associated Society of Locomotive Engineers and Firemen for a 10 per cent increase, and the Transport Salaried Staffs Association for an increase sufficient "to maintain the purchasing power of salaries."

The Railway Staff National Tribunal is the final stage in the agreed negotiating machinery. For the hearing of these claims, Sir John Forster, Q.C., was the chairman, the other two members being Mr. A. J. Espley and Mr. E. Hall, who were respectively nominated by the British Transport Commission and the unions. The majority finding of the tribunal, after a full hearing of both sides, was that it was unable to recommend any wage increase at the present time. The tribunal agreed that the basic rates of the staff covered by the claims were low in comparison with those cited as applying in other nationalised industries, public services and certain private undertakings. But it felt bound to point out that, to cover its deficits up to 1962, the Commission was, by statute, prevented from borrowing a sum in excess of £250 million, against which total it had already been compelled, or would be compelled, to draw amounts which together would exceed £110 million for 1956 and 1957. At the same time, the tribunal emphasised the Commission's view that railway staff would share in the benefit which might be expected to accrue from the modernisation plan, "financially and in their conditions of service." Mr. Hall dissented from the majority finding and recommended the immediate restoration of purchasing power of wages and salaries to the level which obtained following the last increase made in March, 1957. He could not accept the view, he said, that the deficits incurred by the British Transport Commission in its attempts to modernise and reorganise British Railways should be "partially recouped through the worsening of the standard of living of the employees."

The unions were quick to express their extreme dissatisfaction with the tribunal's majority findings. They were ready, however, to accept Sir Brian Robertson's invitation to discuss those findings. In a statement last Friday, Sir Brian said that the tribunal's decision had understandably disappointed the unions, though he believed that their good sense would induce them to deal calmly with the situation. So far as the Commission was concerned, no proposal to give a wage increase at this time, in the face of the tribunal's decision, should be expected. The co-operation of the staff, Sir Brian added, was essential to the success of the British Transport Commission's business; since the wage improvements negotiated in 1956 and 1957, there had been between the Commission and the unions a degree of co-operation which other industries might well envy.

Iron and Steel

British steel output in March was higher than in February; at an average of 432,500 tons a week it was running at an annual production rate of 22,480,000 tons. In the first quarter of this year, however, steel output, at 5,475,000 tons, was slightly below the output achieved in the corresponding quarter of last year. The Iron and Steel Board says that production in the Midlands area in the first quarter was affected by a fall in demand for steel tubes for building, in the Scottish area by some weakness in the demand for light bars, and in South Wales by temporary production difficulties as well as by the withdrawal of older steel works capacity.

Pig iron production in the first quarter of this year, amounting to 3,516,000 tons, exceeded the figure for the comparable quarter of last year. The main increases came from the North East Coast and South Wales. There was a small reduction in the output of pig iron on the North West Coast, but the biggest fall was in the Midlands district, where the output of high phosphoric foundry iron continues to be lower than a year ago. Several merchant iron furnaces are still out of production through lack of demand from the foundries and on account of the closing of older steel works in South Wales.

The Iron and Steel Board reports that during the first quarter of this year the raw materials supply situation was satisfactory. Imports of scrap and pig iron amounted only to 98,000 tons, compared with 229,000 tons and 422,000 tons respectively in the corresponding periods of 1956 and 1957. The rate of these imports is expected to decline further as current contracts are worked off.

Industry's Prospects

The presidential address, which Sir Hugh Beaver delivered at the annual general meeting of the Federation of British Industries on Wednesday of last week, dealt with a number of topics of special importance to British industry at present. During the past year, Sir Hugh said, two major considerations had dominated the whole picture, namely, our economic problems and the European Tree Trade Area proposition. He believed all the signs showed that this country was moving into a situation different from that of the post-war years up to mid-1957. The position in the U.S.A., Sir Hugh continued, was seen to be rather more threatening than during the two preceding American recessions since the war; there were now 10 per cent unemployed there.

The American pace, Sir Hugh went on to say, had been so hot that it was bound to suffer relapses from time to time; this one seemed likely to last until the autumn. In the meantime, world commodity prices had fallen severely so that, at the end of 1957, this country's import prices were 8 per cent lower than at the beginning. At the same time, Sir Hugh added, the "intense and ambitious industrial nationalism" of post-war years, particularly in the newly independent countries, was coming home to roost! All this, he suggested, was going to make things more difficult and more competitive for this country, and the question was whether this country was going to be able to hold and expand its position in an international market. Costs and prices, Sir Hugh emphasised, were the first problems that faced our economy. It was, therefore, not satisfactory to note that last year incomes rose faster than output, the income from employment, namely, wages and salaries, accounting for two-thirds of the 4 per cent increase in home costs.

Employment and Unemployment

During February, the number of people in civil employment in Great Britain declined by 36,000 to a total of 23,057,000 (15,291,000 men and 7,766,000 women). This decline was spread over most sectors of the economy, though one exception was in building and contracting where the number employed increased by 7000 during February to a total of 1,463,000.

In the manufacturing industries, the number of people employed in February was 9,254,000, which was 30,000 fewer than a month earlier. In this group, there was a drop of 11,000 in the manpower of the engineering, metal goods and precision instrument industries bringing the total there at the end of February to 2,834,000; that figure was 9000 higher than a year earlier. The total number employed in vehicle building in February was 1,251,000, indicating a loss of 1000 during the month; the total was, however, 41,000 higher than a year earlier.

About unemployment, the Ministry of Labour reports that on March 17 there were 433,071 people registered as out of work, compared with 424,547 on February 17. The March figure represented about 2 per cent of the working population; it included 395,727 who were wholly unemployed and 37,344 who were temporarily stopped. The Ministry says also that in the week ended March 1 there were about 103,000 operatives in manufacturing establishments who were reported to be on short time, losing thirteen hours each on the average. There were, however, 1,476,000 reported to be working, on an average, seven and a half hours' overtime.

Anglo-Canadian Trade

The President of the Board of Trade, Sir David Eccles, has accepted an invitation to visit Canada for two days, on his way to Venezuela and Brazil. He will meet the Hon. Gordon Churchill, Minister of Trade and Commerce, in Montreal on April 28.

Sir David's visit will coincide with the start of a coast-to-coast tour by a British Dollar Exports Council delegation, led by Sir William Rootes. The visit of this delegation from the United Kingdom follows the successful visit to Britain at the end of last year of the Canadian Trade Mission led by Mr. Gordon Churchill. The British delegation will be promoting further measures for the development of Anglo-Canadian trade and will hold discussions with the Federal and Provincial Governments, the United Kingdom High Commissioner and Trade Commissioners, the Dollar Sterling Trade Council, and the newly established regional committees of leading Canadian industrialists. Arrangements for this tour in Canada have been made by the Dollar Sterling Trade Council, in conjunction with the Canadian Association of British Manufacturers and Agencies. The delegation is to visit Ottawa, Montreal, Halifax, Quebec City, Toronto, Winnipeg, Regina, Edmonton, Calgary, Vancouver and Victoria.

Recent Railway Progress in South Africa

BY OUR SOUTH AFRICAN CORRESPONDENT

A CONSIDERABLE amount of development work is being carried out on the South African Railways, and in the following notes we give general particulars of the progress which was made during the second half of 1957 in connection with some of the work of interest.

Two New Railway Lines

The building of two new railway lines, one as a relief line to the congested Reef area and the other to carry non-European suburban passengers in the Cape, was approved during the year and work thereon has now started. The new Reef line will be built between Natalspruit and Midway, while the one in the Cape will serve as a connecting line between the Cape Town–Simonstown suburban line and the Cape Flats suburban line. Connecting stations will be Southfield and Plumstead.

Enlargement of Bloemfontein Mechanical Workshops

Bloemfontein has been for many years one of the main centres for locomotive repairs, the building of passenger coaches and goods vehicles and the manufacture of boilers. The city's strategic geographical situation, virtually in the centre of the Union, the increasingly heavy rail traffic which is being routed through the Free State, and the mining and industrial development in the province, were all factors in the decision of the Railway Administration to enlarge the mechanical workshops in Bloemfontein. This project, together with certain work which had to be done to railway stores buildings, is estimated to cost over £7,000,000.

New projects now in progress are the second part of the boiler shop, the locomotive erection shop, the machine shop, the blacksmith shop, and the main administrative block. The completed boiler shop will have a floor space of 290,000 square feet, the machine shop 275,000 square feet, the locomotive erecting shop 405,000 square feet, and the blacksmith shop 90,000 square feet.

The iron foundry at Bloemfontein is one of the most modern in the country. In January, 1956, part of the foundry started producing brake shoes at the rate of 157 tons a month, but by the end of the year it was producing 1190 tons a month, with a total of 536,284 brake shoes for the whole year. Early in 1957 another part of the foundry started producing locomotive spares, and the total output in June stood at 110 tons a day. By the end of the year production was pushed up to 200 tons daily, with the foundry producing practically all kinds of spares for locomotives and other rolling stock. The shop has been fully mechanised and modern equipment from overseas has been installed.

Rolling stock repairs have nearly doubled since the new shops went into production. During 1951, while the old shops were still in commission, light and heavy repairs to locomotives, passenger coaches and trucks numbered 2398, but during 1956 this figure rose to 4614. The output was probably doubled during 1957, and by 1960, with all the shops in commission, production will have quadrupled. In addition, thirty-four underframes for passenger coaches were completed by the middle of the year, with 125 hoppers for coal traffic and 150 underframes for guards' vans in hand. A programme for truck building is one of the future projects.

The points and crossings shop, which came into production in 1954, is twice the size of the old one and further extensions are being considered. It is the only shop of its kind in the Union and several kinds of permanent way spares, such as points, crossings, stop blocks and fishplates are turned out. Signalling equipment, with all the necessary accessories, is another product of this shop, whose output has been almost quadrupled, from about 1000 points and crossings per year to more than 3600, and from only four special crossings per month to fifteen.

Due to mechanisation the increase in staff in relation to output has been relatively small. Since 1951, the European staff has increased from 1477 to only 1698, while the non-European staff has increased from 861 to 1168. By 1960, an estimated 3000 Europeans and 1800 non-Europeans will be employed in these workshops.

"Neoprene" Insulation for Steel Sleepers

One of the new methods which is being tried by the South African Railways to improve signalling and in this way to increase the capacity of certain lines and to speed up train services, is the insulation of steel sleepers from the track by means of "Neoprene" pads. The method is very simple and consists of folding a "Neoprene" pad round the flange of the rail, protected by two galvanised overlapping steel envelopes, the rail being then bolted to the steel sleeper by specially designed clips and bolts. The method is clearly illustrated in Fig. 1.

Modern signalling systems rely on electrical circuits in the rails for their operation and these track circuits demand in turn that the running rails should be insulated from one another. Up to now one of the most challenging problems has been the provision of track circuits on many miles of steel sleeper track. To replace steel sleepers with wooden ones which give the necessary insulation between rails can cost upward of £7000 per mile, providing wooden sleepers are available. It is clear that this cost tends to make the use of signalling methods such as centralised traffic control, remote control of interloops and non-token bi-directional signalling almost prohibitive, and a solution of the steel sleeper problem is consequently extremely desirable.

After the qualities of neoprene pads had been determined and their efficiency demonstrated, it was decided to test the "Neoprene" pad installation under practical conditions where burning ash deposits between the rails and water concentrations at water columns had to be contended with. The first trial track circuits on steel sleepers were introduced at Fortuna, on the Union-Volksrust line, last year, and this installation is still functioning satisfactorily.

As a result of experience gained at Fortuna, changes were made in the design and a further section of track on steel sleepers was track circuited near Mapleton, to ascertain how the neoprene insulation stood up to high speed traffic on steep gradients and sharp curves, while, early in 1957, a flashing light installation, using similar track circuits, was brought into use at Swartruggens, on the Johannesburg-Mafeking line.

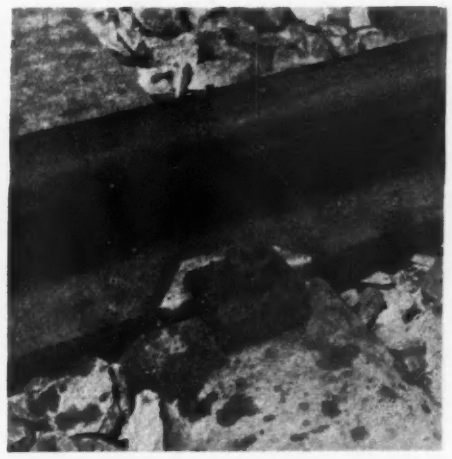


Fig. 1—A "Neoprene" insulation pad in position between the rail and a steel sleeper

Centralised traffic control is being provided on the Kamfersdam-Postmasborg line, where all stations and crossing points will be equipped with electrically-operated signals and points, remotely controlled from a panel at Kimberley. The interlocking at these places will be done by means of track circuiting on existing steel sleepers with an estimated saving of about £242,000 compared with re-sleepering with wood. As a comparison test, axle counters will be provided for control of the block sections between interlockings.

Regional Improvements in Pretoria and District

A new administrative building for the office of the System Manager of the South African Railways at Pretoria, the doubling of the railway track from Capital Park via Koedoespoort to Eerste Fabrieke, a distance of 13 miles, the installation of colour-light signalling plus the electrification of the new double track and the construction of several new lines, are among the modernisation and expansion plans of the South African Railways.

The approved programme to which the administration is working for Pretoria and the area surrounding the city will entail the expenditure of over £18,000,000 and the most recent report shows that good progress is being maintained on all the works in hand. Generally speaking, the various projects should be completed before the original target dates.

Work is now in progress and is well advanced on the doubling and electrification of the line between Capital Park-Koedoespoort-Eerste Fabrieke plus the provision of six new halts, a new station with two 1200ft island platforms at Eerste Fabrieke and a new station with two 720ft platforms at Denneboom. Certain sections of the line are also being rerouted and regraded. A major project which was started soon after the Koedoespoort workshops were opened is the doubling of the line between Pretoria and Koedoespoort, a distance of 6½ miles. This work is now practically completed. Included in the programme is the elimination of three level crossings.

Outsize Kilns Carried by S.A.R.

One of the recent highlights of rail transport in Southern Africa was the conveyance of two cement kilns from the factory of Babcock and Wilcox (Africa) Pty., Ltd., Vereeniging, to destinations in Rhodesia and Nyasaland. The kilns, which measured 55ft 11in and 47ft 7in, constituted one of the biggest single loads (226,000 lb) ever transported by rail in Southern Africa.

A maximum speed of 30 m.p.h. was imposed over the Vereeniging-Westleigh and Orkney Fourteen Streams sections, reduced to 15 m.p.h. over turnout legs of points and cross-overs, while the speed was restricted to 25 m.p.h. over the Fourteen Streams-Bulawayo sections. Several obstructions at stations had to be avoided by the diversion of the load along loop lines, and stops had to be made at all bridges with overhead structures, while the speed was reduced to dead slow at many points. From Bulawayo onwards, tracks alongside station platforms had to be avoided as an additional safeguard. The kilns were carried on two type S.14 wagons as two-point loads which rested on timber supports placed as nearly over the bogie centres as possible. The timber packings extended the full length of the wagons. Timber chocks, shaped to the profile of the load, were fixed to the timber packing to prevent any side movement, while each kiln was firmly lashed down by means of chains attached to four lashing lugs. (See Fig. 2.)

Two cast iron tyres, the size of which can be

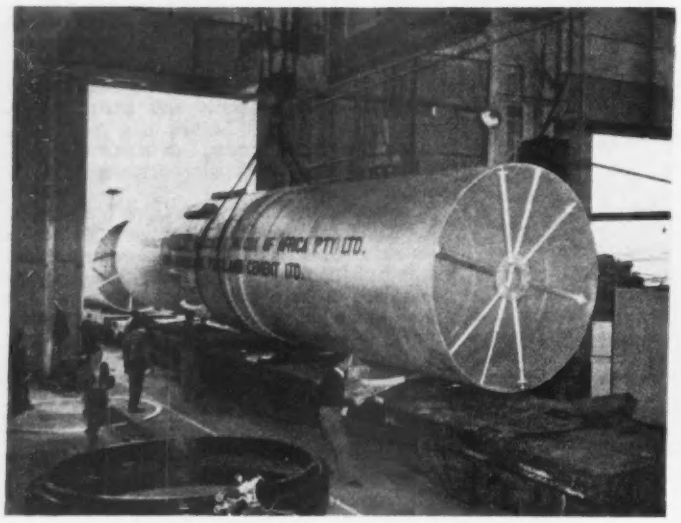


Fig. 2—An overhead crane lowering one of the cement kilns on to a specially converted "S.14" wagon

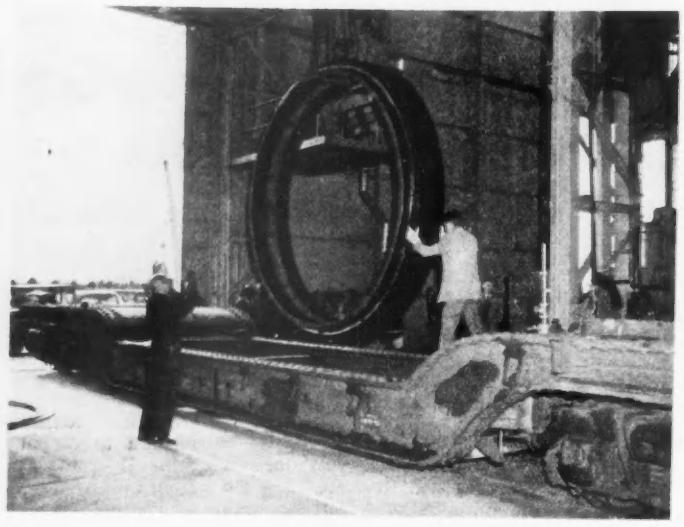


Fig. 3—A cast iron tyre weighing 20,000 lb being lowered into position on a type "U.8" well wagon

seen from Fig. 3, six stiffening rings and one gear ring had to accompany the load. The two tyres, weighing 20,000 lb each, were carried on type U8 well wagons, while the six stiffening rings (in halves) and the gear ring (two sections) were carried together on a type DZ.6 wagon.

Elimination of Narrow-Gauge Lines in South West Africa

The 353 miles of narrow-gauge lines (2ft) which form part of the 1463 route-miles of railway network in South West Africa will, within the next three years, be eliminated.

The railway lines in S.W.A. form an integral part of the South African Railways, and in a further effort to increase the carrying capacity and promote efficiency it has been decided to widen the narrow-guage lines between Kranzberg and Tsumeb (250 miles), Otavi and Grootfontein (57 miles), and Otjiwarongo and Outjo (44 miles), to a 3ft 6in gauge at a cost of £6,250,000. In addition to the relaying of the track, this programme will also mean the replacement of the rolling stock.

The major part of the necessary earthworks will be done by private contract under the supervision of railway engineers. Railway engineers are now surveying the terrain, for, although the new lines will in certain areas follow the routes of the old lines, quite a number of deviations will be necessary to eliminate some of the sharp curves.

The new lines will consist of 60 lb rails, laid on 1920 steel sleepers with 1200 cubic yards of stone ballast per mile, while two major bridges, one across the Kahn River, and the other across the Omaruru River, are to be built. A construction office is being opened at Otjiwarongo, where temporary housing will be provided for the delivery and erection of twenty prefabricated houses. In addition, immediate attention is being given to the locomotive shed at Usakos, which is being enlarged to take the bigger locomotives.

Double-Line Construction in Natal

The doubling of the Mooi River–Estcourt section of the Natal main line was completed in September last, when the first trains used the new tracks. Railway traffic over what was once an extremely difficult section now uses an 8-mile shorter route, while curvature has been decreased by 4000 deg. To bring the new section of double track into use, Estcourt station had to be remodelled to a considerable degree and the old single-line platform scrapped and replaced by two island platforms. The doubling of the main line between Pietermaritzburg and Ladysmith, together with regrading and realignment, was one of the most expensive single works ever undertaken by the South African Railways. The latest estimate is that by the time all the work is completed the cost will be approximately £12,750,000. In the course of improving the Natal main line, full advantage has been taken of the opportunity to eliminate as many level crossings as possible. On the Pietermaritzburg–Ladysmith section, twenty-nine level crossings have been replaced by grade separation structures, while a further crossing is still to be eliminated. On the Volksrust–Union section, thirteen level crossings will be replaced by grade separation structures and a further two will disappear as a result of line deviation.

Work has now started on the Transvaal portion of the Durban–Johannesburg main line and work all along the route gives evidence of the modernisation programme of the South African Railways. Fig. 4 shows electrical work in progress on the line. The amount sanctioned for the improvements to this 135-mile section of the main line is nearly £9,000,000, and the money will be spent on reducing curves and gradients and generally improving the alignment of the line. Some of the earthworks, culverts and bridges, as well as one tunnel ½ mile long, will be done by contract. Several large contracts have already been planned. In addition, three tunnels, with a total length of 9000ft, will be built departmentally. Work has already started on one near the new Kraal station on the Union–Volksrust line. It will be nearly 1 mile long and will shorten the distance between Fortuna and Kaydale by about 3½ miles. Fig. 5 shows this tunnel in process of construction. A vertical shaft will be sunk through the roof of this tunnel down to track level, and by excavating in both directions away from the shaft and from both outer ends of the tunnel towards the shaft, work can be carried out on four faces simultaneously. Work on this section is expected to be completed in 1959, but portions will come into use this year.

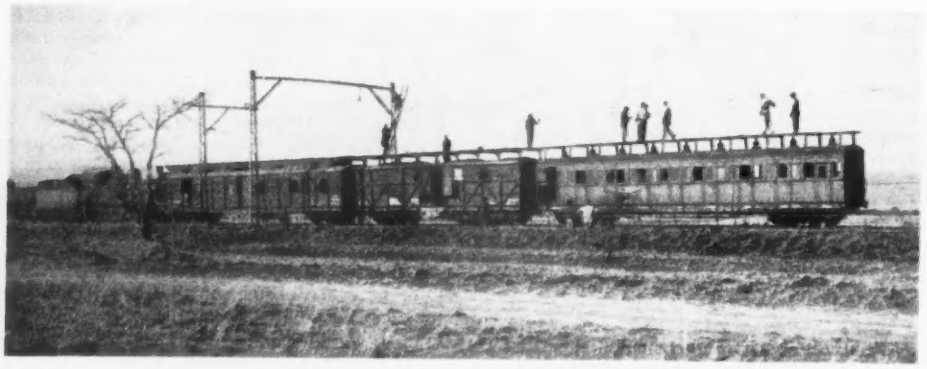


Fig. 4—Electrification work in progress on Natal line

Fig. 5—Broken rock being removed from a tunnel under construction on the Natal main line

Interferometer for Measuring Gauge Block Parallelism

BY OUR AMERICAN EDITOR

A MORE rapid and convenient measurement of the parallelism of opposite faces of gauge blocks is now made possible by an interferometer recently designed by the National Bureau of Standards, of Washington, D.C. The instrument is adjusted by a few simple and stable controls, and the angle between the gauge block surfaces is read directly from a calibrated scale. The use of the interferometer is expected to improve the efficiency of gauge block calibration in a wide range of industries where the blocks serve as reference standards for high-precision manufacturing operations. For a growing number of processes, as in the making of machine tools, ball bearings, and missile control mechanisms, test gauges for dimensional control must be accurate to within 1/100,000 of an inch; and the gauge blocks used in checking the accuracy of the gauges must be more accurate still. The use of interferometers permits the gauge blocks themselves to be measured with errors of less than a small fraction of a wavelength of the light used.

The present instrument, which is shown in Fig. 1, was developed as part of a programme whose goal is a substantial increase in the accuracy of dimensional standards for industry. In view of the industrial importance of this programme, a group of private firms has supplemented the Bureau's Congressional appropriation with additional funds to help support the necessary research. Among the previous results of this work is an interferometer for comparing the linear dimensions of gauge blocks to an accuracy of one part in 10,000,000.

As in other interferometers, the basic principle utilised in the present instrument is that if two beams of light from the same source travel along different paths and then come together again, they will form a pattern of interference fringes, the number of fringes depending on the difference in optical path length. Usually, the two beams are reflected from different surfaces, so that the fringes give information about the relative position of the two surfaces. However, the application of the interference principle here is somewhat more complex. Looking through the eyepiece, one sees two separate interference patterns, one for each of the gauge-block surfaces being compared. Each pattern is formed by the interference of light rays reflected from different parts of the same surface, a result obtained by using a double-image prism. If the two block surfaces are parallel, the fringe patterns are also parallel; otherwise the two sets of fringes are inclined by an amount that depends on the angle between the surfaces. However, by placing a glass wedge in the path of the rays and rotating it to the correct position, the fringe patterns may be made parallel. The angle between the two surfaces can then be read directly from a suitably calibrated scale attached to the wedge, as shown in Fig. 2.

In previous applications of interference to the measurement of gauge block parallelism, the procedure has been to wring the block on to an optically flat surface and to measure by interferometric means the angle between the upper surface of the block and the exposed portion of the optical flat. The wringing involves contact with the hand, which raises the block temperature and may entail a long wait for temperature equilibrium to be established; it also causes undesirable wear of the gauge block surfaces. The present instrument avoids both of these difficulties by measuring the angle between the opposite faces of the block by a direct comparison of the two faces. Although its optical arrangement is more complex, preliminary tests show not only that it can be operated more easily, but that the operating procedure can be reduced to a simple routine.

In outlining how the instrument works, it is convenient to proceed in three stages, describing (1) the principal components and their arrangement, (2) the basic manner of operation, and (3) the refinements that make possible a direct reading of the angle.

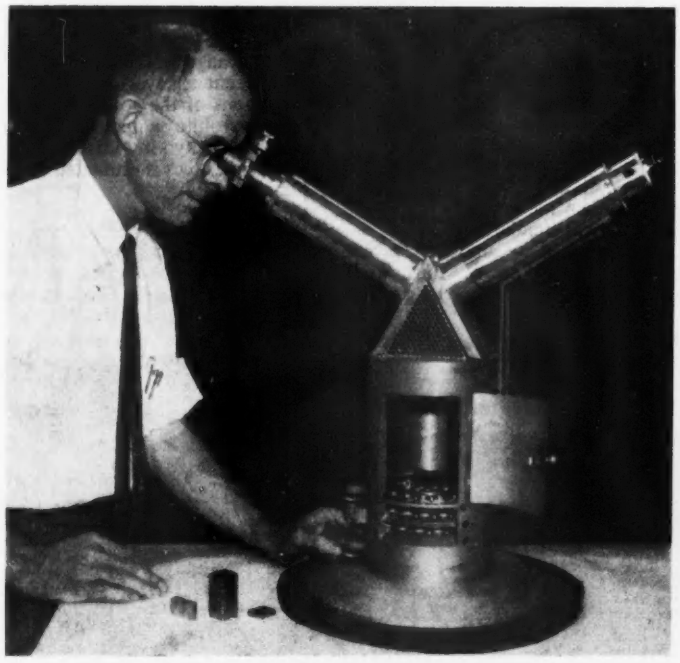


Fig. 1—N.B.S. interferometer for testing the parallelism of gauge block surfaces

Principal Components

The principal optical components are a double-image Kösters prism and a right-angle prism. The double-image prism is made by taking two 30–60–90 deg. prisms, depositing a semi-transparent layer of aluminium on a face of one of them, and cementing the two together with the aluminised face on the inside. The resulting unit is a 60–60–60 deg. prism which is "split" down the middle by the semi-transparent layer. The right-angle prism is used for its well-known property that a ray of light entering through the base along any line perpendicular to the 90 deg. edge will emerge, after two internal reflections, along a path exactly parallel and opposite to its original direction. In describing the arrangement of the various components, it is useful to refer to the "central plane," which contains the aluminised layer; and to the "transverse plane," which is perpendicular to the central plane and passes through the centre of the double-image prism.

The double-image prism is mounted with its base (face bisected by the aluminium film) downward and horizontal; and the right-angle prism is about a foot directly below with its base upward and its 90 deg. edge in the transverse plane. The gauge block to be measured is supported on a perforated plate between the two prisms. It is placed to one side of the transverse plane and so that its upper and lower surfaces (the angle between which is to be measured) are approximately horizontal and are bisected by the central plane. Light from a point source is collimated into a parallel beam, the collimator axis being normal to one of the upper surfaces of the double-image prism. A viewing tube, containing an objective lens and a micrometer eye-piece, has its axis normal to the other upper surface.

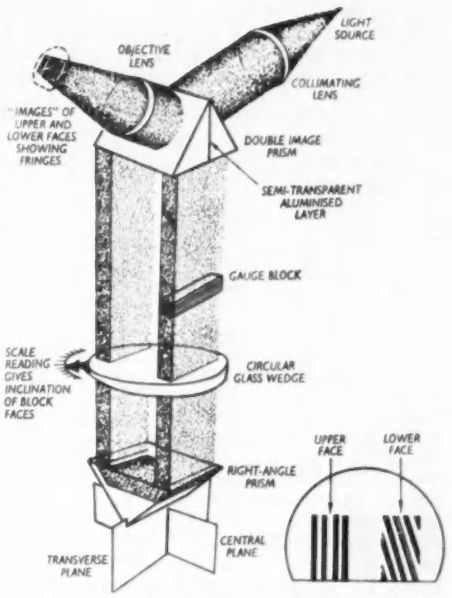


Fig. 2—Diagram showing the optical system employed in the N.B.S. interferometer

Basic Operation

The parallel beam from the collimator passes through the double-image prism to the semi-transparent layer, where each of its rays is divided into two parts; one continues ahead to the opposite face and is internally reflected straight downward; the other part is bent back to the face through which it entered and is there reflected downward. The two emerging rays (which derive from a single original ray) are symmetrical with respect to the central plane. Some of the rays on one side of the transverse plane strike the top surface of the gauge block and are reflected back to the prism. If the surface is perpendicular to the rays, both members of a symmetrical pair are reflected back along their paths to the semi-transparent surface. Here each ray is again split, and half of one combines with half of the other to emerge along the same line towards the viewing tube.

Similar remarks apply to rays on the other side of the transverse plane, except that these pass through the right-angle prism and emerge vertically upward. Some of these strike the lower surface of the gauge block. If this is perpendicular to the rays, a given symmetrical pair will be reflected back along their paths and, by the process described, combine to form a single ray moving toward the viewing tube. Rays that do not strike the gauge block are internally reflected in the right-angle prism, each ray of a pair moving up along the path by which the symmetrical ray had descended. As before, the two rays are re-combined at the aluminised surface and proceed to the viewing tube, where they form the background of the field of view.

The first step in using the instrument is to adjust the control knob, if necessary, to orient the right-angle prism so that its base is perpendicular to the rays. When this is the case, all light paths for rays that do not strike the gauge block are equal and no interference fringes appear in the background of the field. (More correctly, one sees a small portion of a very broad fringe; in the limiting case, the width of this fringe would be infinite.) With a second control adjustment, the mounting plate on which the gauge block rests is oriented so that the upper block surface is

also perpendicular to the rays, as indicated by the absence of fringes in the part of the field corresponding to the upper surface. The appearance through the eyepiece of the lower surface of the block now indicates the size of the angle, if any, between it and the upper surface. If the surfaces are parallel, the lower one is also perpendicular to the rays, and no fringes appear; and the more fringes the greater the angle between the surfaces.

It should be noted that the instrument measures one "component" of the inclination at a time. Hence, any sufficiently small inclination can be thought of as obtained by rotating the surface from the position of zero inclination successively about two perpendicular axes lying in the surface. The instrument measures only that part of the inclination corresponding to rotation about the line in which the surface intersects the central plane. In the basic instrument as described thus far, the fringes will be parallel to this line. To measure the other component of the inclination, the block is rotated through 90 deg. In either case, if 2·6 fringes are observed, for example, the component of the inclination is equal to $2{\cdot}6\lambda/2L$ radians, where λ is the wavelength of the light and $2L$ is the dimension of the block perpendicular to the central axis.

Direct Reading of Inclination

Two additional features permit a direct reading of the inclination. Without changing the basic optics of the instrument as described above, this results in an important gain in speed and convenience. First, while the cement between the two halves of the double-image prism is still soft, the two parts are twisted slightly with respect to each other. The twist—a rotary, sliding motion of the two surfaces separated by the cement—amounts to only a few seconds of arc. As a result, the two beams emerging from the base on either side of the central plane are no longer exactly symmetrical; however, each remains parallel to the central plane.

The effect of this can be seen by supposing the instrument to be adjusted in the manner described above. When the upper face of the block is set perpendicular to the rays, it now exhibits a permanent set of fringes perpendicular to the central plane. If the lower block surface is parallel to the upper one, it will exhibit a set of fringes parallel to those of the upper surface. However, if it has a component of inclination about a horizontal axis in the central plane, the fringes are turned through an angle that depends on the size of that component. This angle can be measured with the help of the micrometer eyepiece, and from the angle one can calculate the inclination. Direct reading of the inclination can now be obtained with the help of a circular glass disk cut from a glass plate whose faces are inclined to each other. This circular wedge, placed between the gauge block and the right-angle prism, can be rotated about a vertical axis and its position is indicated on a circular scale.

The wedge introduces a controllable amount of difference in the optical paths of the two rays of a symmetrical pair. When the planes of the wedge are perpendicular to the central plane, the two paths are changed by equal amounts and the fringe pattern is unaffected. In other positions of the wedge, the two paths are affected differently; and by suitably adjusting the position it is possible to compensate for the inclination of the lower block surface. When this is done, the fringes from the lower surface have the same appearance as those from the upper surface. Thus the angular position of the wedge required to produce compensation depends on the amount of inclination; so that a direct reading of the inclination is achieved by a suitable calibration of the associated scale. Monochromatic light must be used in the calibration procedure; thereafter, since the instrument operates on a null principle, it can be used with white light.

Redetermination of the Standard Ampere at the N.B.S.

A RECENT experiment at the National Bureau of Standards, Washington, D.C., has shown that the standard ampere maintained by the Bureau has drifted no more than a few parts per million in the last fifteen years. Such a small apparent change may well be due to slight errors in measurement, so that the standard ampere may actually have remained perfectly stable since its original evaluation in 1942. Because of the importance of precise electrical measurements to modern science and industry, the Bureau maintains permanent primary standards of two basic electrical quantities, voltage and resistance. From these basic electrical standards, the Bureau has derived other standards for all electrical quantities in use to-day. One of these, of course, is electric current. Because current is transitory, the primary standard ampere cannot be kept in the form of a material object such as the standard cells that maintain the volt or the standard resistors that maintain the ohm. Each time the standard ampere is required, it must be obtained anew from the standard volt and the standard ohm by use of Ohm's law. However, a gradual change might sometimes occur in the standard cells or the standard resistors. One method of checking the stability of these standards is to compare the standard ampere derived from them with the "absolute" ampere, that is, the ampere obtained experimentally in terms of mechanical units of length, mass, and time.

In the present determination, the Bureau measured the standard ampere in absolute amperes using two different sets of apparatus. One was the current balance used in the 1942 evaluation; the other was a Pellat electrodynamometer, which was introduced to reduce the possibility of systematic errors. The standard ampere was found to equal 1·000008 absolute amperes by the current balance method and 1·000013 absolute amperes by the Pellat instrument. The weighted mean of these two values is 1·000010 absolute amperes, but in this mean there is an uncertainty of five parts per million. If no accidental errors were made in either the original or the present evaluation and if all systematic errors remained fixed, then the value of the current yielded by the electrical standards of resistance and voltage has decreased by six parts per million. On the other hand, known sources of accidental error in the current balance determinations could easily account for the apparent drift.

The Current Balance

The ampere was evaluated with helical coils by determining the mechanical force between the two parts of the circuit through which

Fig. 1—Helical coil balance used in the redetermination of the standard ampere

the current flows. In the centre of two large fixed coils, a smaller coil is hung from the arm of a precision balance, as shown in Fig. 1. All three coils carry the current to be measured, but the current in the fixed coils can be reversed. The electromagnetic force developed by the current in the coils tends to pull the movable coil downward for one direction of the current in the fixed coils but tends to lift it when this current is reversed. From the change in the force on the balance when the current is reversed and from the measured dimensions of the coils, the value of the current in absolute amperes can be computed. The uncertainty in this method arising from all known sources is estimated to be six parts per million.

The Electrodynamometer

The modified Pellat electrodynamometer is illustrated in Fig. 2 and consists essentially of a long stationary horizontal solenoid 28cm in dia-

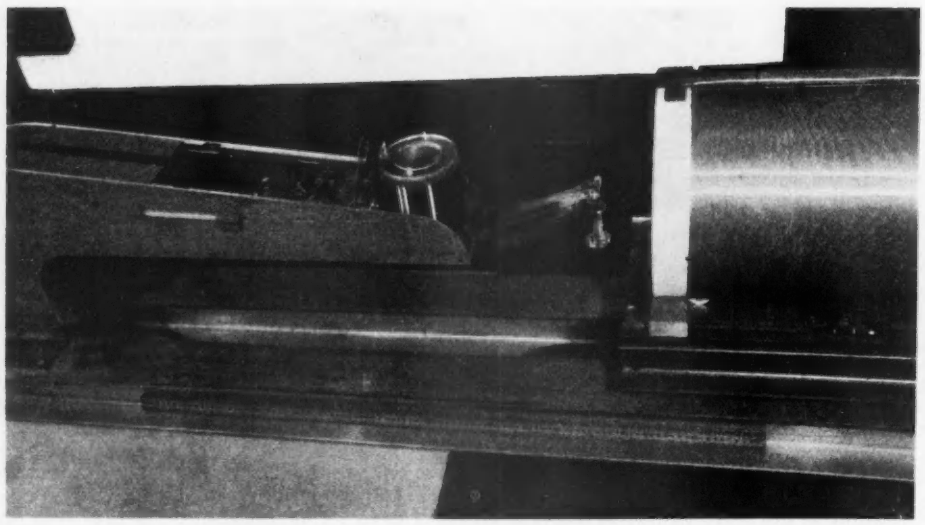


Fig. 2—Modified Pellat electrodynamometer used in the redetermination of the standard ampere

meter, a short solenoid 11·6cm in diameter, and a balance. The smaller coil, which is mounted on the balance beam, is inserted into the longer solenoid so that the coil axes are perpendicular. Current in the outer solenoid produces a magnetic field which is essentially constant at its centre. When the coils are connected in series an electromagnetic torque on the smaller solenoid is produced. The small coil therefore tends to tip. Since the balance beam rests on a knife edge, the tipping of the coil attached to the beam upsets the balance. The system is restored to equilibrium with a suitable counterweight. When the current in the stationary coil is reversed the coil tips the other way and equilibrium is restored by placing a mass on the end of the balance arm. During this operation, the current was held constant at about 1·02A, the value being determined by the standard cell and standard resistor. These standards were maintained at a constant temperature and compared from time to time with the Bureau's primary standards. The mass which counteracted the change in torque was adjusted by trial and later evaluated by comparison with known standards. A calibrated scale on the balance allowed for small corrections to the balancing mass. From the known value of the balance weight, the length of the balance arm, and the geometry of the windings, the value of the current was calculated.

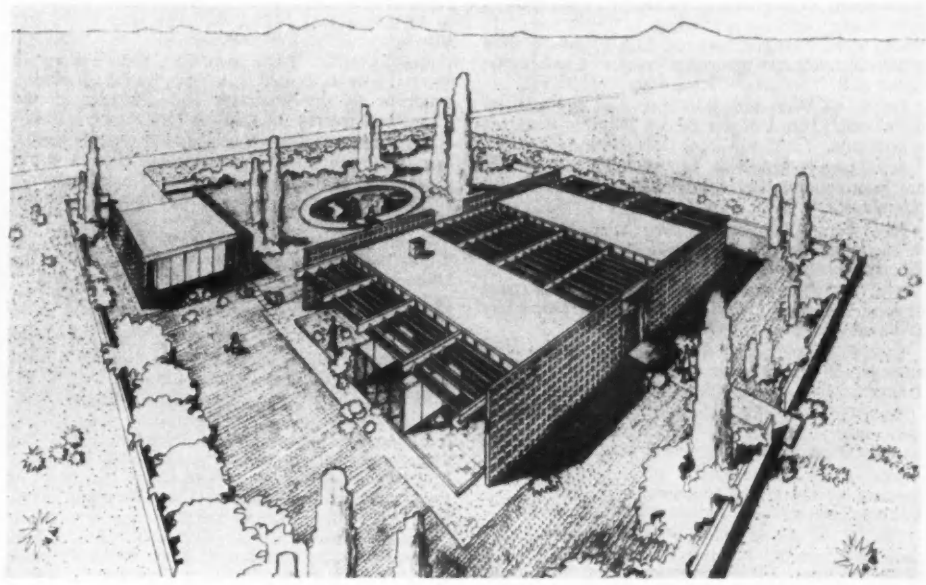
The Bureau's electrodynamometer differs from Pellat's original in several ways. One such difference is its single-layer helical windings. The dimensions of the single-layer windings can be easily checked, whereas the uncertainty in the dimensions of the original balance introduced a source of error. The materials used in constructing the coils also differ from those used in the original. The stationary coil form and balance beam are of fused silica, the rotatable coil form is " Pyrex " glass, and the winding is of oxygen-free copper wire. Special care was taken to ensure low magnetic susceptibility in all parts. For example, aluminium alloys were used in the balance supports, and the brass and phosphor bronze parts of the balance arrestment mechanism were tested for susceptibility.

The pitch of the stationary coil, the diameter of the rotatable coil, and the length of the balance arm are critical parameters in the current evaluation. In making an accurate determination, the pitch of the stationary coil was measured by a micrometer method. Longitudinal readings for the measurement of pitch were taken at several places along the coil in each of six angular positions around the winding. The diameters of both coils were also measured with considerable precision. Although the stationary coil diameter did not have to be known accurately for the current evaluation, such a measurement is necessary should the coil be developed into a standard of inductance. The uncertainty in this method is eight parts per million. The major source of this uncertainty is the limited accuracy with which the radius of the rotatable coil could be measured. The Bureau considers it possible ultimately to reduce uncertainty in the radius measurement by a factor of two so that the electrodynamometer will be as accurate an instrument as the current balance.

Construction of Solar-Heated House in Arizona

A SOLAR-HEATED house, designed especially for " living with the sun," is now being erected in the Paradise Valley, 8 miles north-east of Phœnix, Arizona. The house is being built from the design which won for Peter R. Lee, of Minneapolis, the 2500-dollar first prize in the International Architectural Competition conducted in 1957 by the Association for Applied Solar Energy. Lee is an undergraduate student at the University of Minnesota and is affiliated with the architectural firm of Bliss and Campbell.

The new solar house incorporates a unique solution to the related problems of heating the house and warming the swimming pool during the winter, minimising the cooling load during the summer, and supplying the domestic hot water requirements throughout the year. Movable louvres over the north and south patios and the central court serve both as solar energy collectors in winter and as shade producers in summer. The louvres will be adjusted automatically each day to assume the most effective angle for either collecting the sun's energy when heat is needed in the house and the swimming pool, or for reflecting unneeded radiation during the summer months. The louvre collectors will warms the floors in winter and cools them in summer before entering the rooms through grilles which are located in front of the glass walls on the north and south faces of the house. The combination of radiant and convection cooling and heating is expected to enable the house to be maintained at comfortable temperatures with a minimum of heat addition in winter and heat



Artist's rendering of prize-winning design for the Solar house, now under construction near Phœnix, Arizona

be used in conjunction with an insulated underground tank in which hot water will be stored for heating the house at night and during short periods of sunless winter weather. Auxiliary heating during protracted cold spells will be supplied by heat pumps contributed by the Carrier Corporation. Fans in the heat pumps will circulate conditioned and filtered air through the house at all times, and summer cooling will be accomplished by the conventional cooling cycle of the Carrier units.

New products from some of the leading American industrial laboratories will be used in the solar energy collectors. DuPont has contributed the " Mylar " film which will cover the collectors and the " Dacron " which will insulate them. Revere Copper and Brass, Incorporated, has donated the copper " Tube-in-Strip," which will collect the sun's radiation and heat the water which will carry the collected energy to the heating system of the house. " Solar Black " paint, newly developed by the Farboil Paint Company of Baltimore, will be used to coat the copper collecting surfaces. The collector units will be fabricated by Goettl Brothers Metal Products, Incorporated, of Phœnix, from aluminium sheeting contributed by the Reynolds Metals Company. The actual construction of the house is being supervised by the Solar Energy Committee of the Phœnix Association of Home Builders.

An interesting feature of the solar house will be a complete set of instruments by which every aspect of its performance can be measured. A grant from the John B. Pierce Foundation of Connecticut, has enabled the Association for Applied Solar Energy to procure instruments to measure the amount of solar energy which falls on the house, and to determine the amount of heat picked up by the collectors and the temperature at significant places on, in and under the house. The power used by the heat pumps and circulating pumps and fans will also be recorded. The use of the swimming pool as an emergency source of winter heat and as a means of precooling the air going to the refrigerating system in summer will be an unusual aspect of the solar house. Another novel feature will be the use of " Airfloor," a system by which the poured concrete floors of the house are supported on a network of metal domes placed over a sub-floor. Conditioned air, circulating through these domes, removal in summer. The completion of the house is scheduled for this spring, at which time it will be put on public exhibition. The home will serve as the focal point for the Solar House Symposium which will be held in Arizona in September, 1958, by the Association for Applied Solar Energy.

Full details of the above house and the other fifty-nine designs for solar-heated residences submitted in the International Architectural Competition are published in *Living with the Sun*, Volume 1, published by the Association for Applied Solar Energy, 3424, North Central Avenue, Phœnix, Arizona, price 6 dollars.

Accelerated Reclamation Programme

DETAILS have been announced of the accelerated reclamation construction programme included by the President in his statement on measures to improve the national economic situation. An increase of 70,823,000 dollars in the budget request for the fiscal year 1959 is contemplated, including 45,823,000 dollars for expediting construction now under way. This would increase the construction budget for the U.S. Bureau of Reclamation for the year starting in July to 232,685,000 dollars, including planning money for both the Missouri River and the Colorado River Storage Projects and for loans for small projects to be constructed by local irrigation districts or similar organisations.

The added funds, if appropriated by Congress, will permit expedited construction on going work on the Trinity River division of the Central Valley Project in California, the Glen Canyon dam on the Colorado River Storage Project in Arizona, and the Columbia Basin Project in Washington State. An additional 20,000,000 dollars has already been requested for work this year on the Glen Canyon dam and the Trinity River unit of the Central Valley Project. The funds are contained in a supplemental appropriation bill which is now in conference. The revised programme also contemplates that prime construction contracts may be let for the Flaming Gorge dam in Utah and the Navajo dam in New Mexico, other key storage structures of the Colorado River Storage Project.

Personal and Business

Appointments

MR. W. F. CLARKE has been appointed general manager of Millspaugh-Wimpey, Ltd.

JOHNSON AND PHILLIPS, Ltd., has announced that Sir Richard Ernest Yeabsley has been appointed a director.

MR. S. H. EKEFALK and Mr. Erik Ryd have been appointed deputy managing directors of Atlas Copco A.B.

DR. E. G. WEST has been appointed chairman of the research board of the British Welding Research Association.

MR. JAMES E. ROBINSON, M.I.Mech.E., M.I.Mar.E., has been appointed chief engineer of Hepworth and Grandage, Ltd.

MR. PETER ROCHS has been appointed public relations officer of Austin Crompton Parkinson Electric Vehicles, Ltd.

MR. W. J. WESTON, Assoc.I.E.E., has been appointed Birmingham area manager of Lancashire Dynamo Group Sales, Ltd.

MR. F. MOORE has been appointed deputy chief engineer of Steel, Peech and Tozer, branch of the United Steel Companies, Ltd.

THE COMBUSTION ENGINEERING ASSOCIATION announces that Mr. S. P. Chambers has been appointed president for the year 1958–59.

MR. J. M. L. HOWELL, sales manager (earth-moving) of Distington Engineering Company, Ltd., has also been appointed sales manager (mining).

MR. R. K. SAUNDERS has been appointed export sales manager of Ferranti, Ltd., and Mr. J. C. Heywood has been appointed instrument sales manager.

MR. GAVIN MURISON has been appointed Birmingham office manager and technical representative of G. and J. Weir, Ltd., in succession to Mr. Leslie C. Brown, who has retired.

MR. S. H. CLARKE has been appointed director of the new research station now being built for the Department of Scientific and Industrial Research at Stevenage, for fuel and process research.

MR. BRIAN H. TURPIN, managing director of Q.V.F., Ltd., has been appointed managing director of Quickfit and Quartz, Ltd. Both companies are members of the Triplex group of companies.

THE BRITISH TRANSPORT COMMISSION has announced the following appointments :—Mr. C. J. Doyle, to be instructor, Work Study Training Centre, The Grove, Watford ; Mr. W. J. Hills, to be telecommunications assistant.

CROFTS ENGINEERS (HOLDINGS), Ltd., has announced the appointment of Mr. Granville Horsley as a director, and also his appointment as joint managing director of the operating company, Crofts (Engineers), Ltd.

CRAVENS, Ltd., has announced that Mr. Sydney White, M.I.Loco.Eng., and Mr. Gilbert Keith Johnston, A.M.I.Mech.E., have been appointed directors. Mr. White has been appointed technical director and Mr. Johnston, commercial director.

THE INSTITUTION OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND announces that Professor James Small, D.Sc., Ph.D., has been elected president for 1958–59, and that Mr. J. A. Campbell Brown, B.Sc., and Dr. A. W. Davis have been appointed vice-presidents for 1958–61.

THE NATIONAL BOILER AND GENERAL INSURANCE COMPANY, Ltd., has announced that Mr. E. G. Nisbett has been appointed metallurgist to the company, in succession to Mr. A. H. Goodger, who is retiring. Mr. Goodger's services are being retained on a consultative basis.

C. P. WAKEFIELD, Ltd., announces that Mr. W. A. Thompson and Mr. R. D. Honey have been appointed as contracts engineers in the power generation division. Mr. M. Wiseman has been appointed as contract engineer in the metal industries division. Mr. A. G. Perring has been appointed systems engineering representative covering the process industries for the North of England and Scotland.

Business Announcements

WARREN, MORRISON, Ltd., states that its new address is 41, St. James's Place, London, S.W.1 (telephone, Mayfair 9895).

ENGLISH RACING AUTOMOBILES, Ltd., states that the registered name of the company has been changed to Engineering Research and Application, Ltd.

MR. A. H. GOODGER, head of the metallurgical department of the National Boiler and General Insurance Company, Ltd., has retired from full-time service.

E. H. JONES (MACHINE TOOLS), Ltd., has announced the completion of its new premises at Edgware. Its London area address is now 48, High Street, Edgware (telephone, Edgware 4488/9).

BRITISH INSULATED CALLENDER'S CABLES, Ltd., states that the address of its Hull branch office will be 49, Mytongate, Hull (telephone, Hull 16470 and 16367), with effect from April 21.

HUBERT H. P. TRIST AND CO., Ltd., announces that it is now licensed to manufacture asbestos friction materials to the processes and formulæ of the Thermoid Company of Trenton, New Jersey, U.S.A.

THE PLESSEY COMPANY, Ltd., and Brayhead (Ascot), Ltd., have announced that they have entered into a joint development and manufacturing agreement covering television tuners and f.m. permeability tuners.

ELGAR MACHINE TOOL COMPANY, Ltd., states that it has been appointed exclusive distributor in the United Kingdom for the horizontal radial, drilling and milling machines manufactured by Mecof of Ovada, Italy.

NORTHERN ALUMINIUM COMPANY, Ltd., announces that a central buying department has been established at the company's head office in London. Mr. D. A. Corbett-Thompson has been appointed chief purchasing officer.

ROTARY HOES, Ltd., West Horndon, Essex, has announced that its offices at Spalding, previously called Rotavators, Ltd., will in future be known as Rotary Hoes, Ltd., Regional Office, Westlode Street, Spalding, Lincs.

EAGRE CONSTRUCTION COMPANY, Ltd., East Common Lane, Scunthorpe, Lincs, has announced that it has taken over the Isca Foundry Company, Ltd., Newport, Monmouthshire. Mr. John Spafford is now chairman and managing director of both companies.

THE BOARD OF TRADE announces that Mr. J. K. Vaughan-Morgan, Minister of State, Board of Trade, and chairman of the Advisory Council on Middle East Trade, and Mr. W. H. McFadzean, vice-chairman and industrial leader of the Council, will visit Middle East countries during May and June this year.

GRESHAM TRANSFORMERS, Ltd., Hanworth, Middlesex, states that owing to the expanding activities of the Gresham Transformer Group, Mr. John P. Coleman, M.I.E.E., chairman, has resigned from the board of Data Recording Instrument Company, Ltd., and no longer has any financial interest in the company.

BX PLASTICS, Ltd., states that it is extending the manufacture of expandable polystyrene at its Brantham works, and that this material will be marketed solely by British Resin Products, Ltd., under the registered trade mark " Distrene," and by Expanded Plastics, Ltd., under the trade name " Polyzote."

ELLIOTT BROTHERS (LONDON), Ltd., states that its power plant division has moved to larger office premises adjacent to its associate James Gordon and Co., Ltd., Dalston Gardens, Stanmore, Middlesex (telephone, Wordsworth 0269). The move covers sales projects and contracts office only, engineering and production remaining at the Lewisham works.

Contracts

F. PERKINS, Ltd., Peterborough, has received an order to supply 3050 diesel engines to Yugoslavia. The contract includes 2250 three-cylinder " P3 " engines for installation in Massey-Ferguson " 35 " tractors and 800 four-cylinder " P4 " engines for the Yugoslav-built " Zadrugar " tractor. Deliveries will be completed by the end of the year.

Miscellanea

INDUSTRIAL BUILDING.—The Board of Trade has stated that, in the first quarter of this year, 583 development certificates for industrial building were issued, the total area involved being 11,800,000 square feet. The figures relate to approved schemes for new buildings and extensions to existing buildings, of more than 5000 square feet, for manufacturing industry.

ROYAL SHOW AT BRISTOL.—Every year at the Royal Show, silver medals are awarded by the Royal Agricultural Society for " new machines or appliances with definite application to agriculture, horticulture or estate services, which are new in principle or purpose." For this year's awards, thirty-one entries (including two deferred from last year) were made. Sixteen of these entries have been accepted for judging, subject to test reports being made available before the Royal Show which opens at Bristol on July 1.

WELD INSERT FOR PIPE JOINTS.—Rockweld, Ltd., Commerce Way, Croydon, Surrey, has introduced the " E.B." weld insert process to this country. This form of weld insert is used for pipe joints where a root run weld must be of the highest quality. It comprises a wire of special section, which is fitted between the prepared ends of the pipes to be joined, and subsequently fused to provide an efficient weld and a smooth contour, both internally and externally.

IRON AND STEEL INSTITUTE AWARDS.—The council of the Iron and Steel Institute has announced the award of the Bessemer Gold Medal for 1958 to Mr. W. F. Cartwright (Steel Company of Wales, Ltd.), and the Sir Robert Hadfield Medal for 1958 to Mr. W. C. F. Hessenberg (British Iron and Steel Research Association). Two Ablett prizes of £50 each are awarded to Mr. C. E. H. Morris and Mr. R. N. Dale (Steel Company of Wales, Ltd.), for their paper entitled " Planning the Conversion of a High-Lift Slabbing Mill to a Universal Mill."

HELICOPTER LANDING STATIONS.—Two applications to the London County Council for permission to build helicopter landing stations on the Thames are to be the subject of public inquiries before being determined by the Minister of Housing and Local Government. Rotorports, Ltd., has applied for permission to establish a floating pontoon on the river by the Albert Embankment, Lambeth, for use as a helicopter station, and Westland Aircraft, Ltd., has applied to build a heliport, which would include a landing stage partly over the Thames, at Belmont Works, York Road, Battersea. The inquiry into the first application begins at 10.30 a.m. on Thursday, May 8, at the County Hall, and the inquiry into the second application will follow a week later, on May 15, at the same time and place.

MINIATURE ELECTRIC MOTOR FOR SMALL SERVO SYSTEMS.—A miniature electric motor with a no-load speed of 9000 r.p.m. and a stalling torque of 8 gm centimetres and measuring 1·6in (40mm) overall by 0·625in (16mm) outside diameter, has been introduced by Smiths Aircraft Instruments, Ltd., Cricklewood, London, N.W.2. The motor (size 7) is fully " potted " and built with non-corrodible laminations, and is designed particularly for use in small servo systems, as in guided missiles, for example. It can be operated on a single-phase, 26V supply, in conjunction with a 1·5μF tuning capacitor or from a two-phase, 400 c/s supply. In one of its available forms it can be operated directly from a pair of germanium transistors connected to the centre-tapped control phase.

INDEX OF FILMS ON CHEMISTRY.—The Royal Institute of Chemistry is preparing an index of films on chemistry, including chemical techniques, research or manufacturing processes, and would welcome details of any professional or amateur film that is available on loan or for hire, but is not listed in the general film catalogues. Material for this index is being collected by Dr. J. H. Pryor, 3, Forsyte Crescent, Upper Norwood, London, S.E.19, to whom relevant information should be sent. The particulars required are : the title, length, the sponsor and distributor, whether black and white or colour, whether 16mm or 35mm, whether available on free loan or for hire, a brief account of the contents of the film, and the audience for which it would be suitable. It is intended to make the index as complete as possible so that up-to-date information about films will be available, on request, to those who are responsible for organising scientific film shows and to teachers of chemistry.

WATER-LUBRICATED BEARINGS.—On March 31 a paper entitled " Water-Lubricated Bearings for Marine Use " was read by A. D. Newman, B.Sc., before the North East Coast Institution of Engineers and Shipbuilders. In the paper the properties of water as a lubricant are discussed and the problems of practical hydrodynamic lubrication with water are shown to be capable of solution. From this basis, two general marine bearing applications are considered, the first involving large relatively low-speed bearings, and the second smaller high-speed bearings. For bearings in the first category, such as stern-tube and A-bracket bearings, it is common practice to use water as the lubricant, but it is shown how such bearings may be considerably improved in the light of water lubrication research, and full-scale tests culminating in service in a warship are described. For smaller high-speed bearings, in which at present the lubricant is almost universally oil, it is suggested that in many instances considerable advantage would be gained by using water lubrication. To illustrate the feasibility of this, the development of water-lubricated journal and thrust bearings suitable for a main turbine is described, together with the operation of a turbine with such bearings, and the practical implications of this work are discussed.

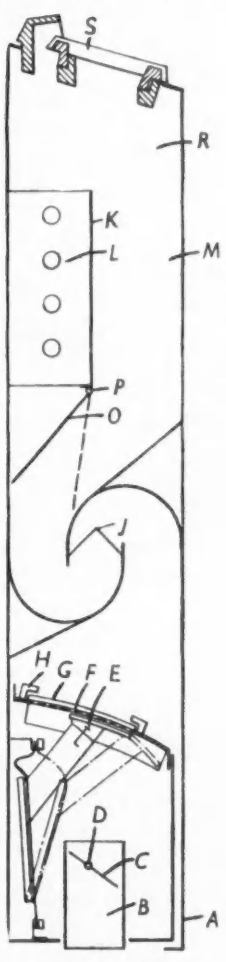
British Patent Specifications

When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification. Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 3s. 6d. each.

HEAT EXCHANGERS

791,970. October 17, 1955.—REGULATING THE FLOW OF A GASEOUS MEDIUM, Aktiebolaget Svenska Flaktftabriken, Kungsgatan 18, Stockholm, Sweden.

The invention relates to a regulating device in apparatus provided with a heat exchanger for treating a gaseous medium, and a by-pass arranged side by side with the means, the regulating device being intended for simultaneous regulation of the quantity of passing medium as well as the ratio between treated and non-treated medium. The drawing shows a cross section through an apparatus, provided with the regulating device of the invention. *A* is an apparatus provided with an inlet *B* for the medium. In the inlet there is a throttle *C* which may be turned about an axle *D*. *E* is an automatic volume governor which is associated with the lower face of a partition *F* across the apparatus and provided with one or more apertures. The size of the effective area of the apertures is regulated by a damper *G* which is movable and guided by the rails *H* and which co-operates with the upper face of the partition *F*. In the drawing an embodiment of a sound deadener is designated *J*. Above the sound deadener the apparatus is divided by means of a partition *K* into a space for a treating means *L* and a by-pass *M*. The ratio between treated and by-passed non-treated medium is regulated by a damper *O*, which is swingable about an axle *P*. This damper can be put in any intermediate position. The medium passing the treating means and/or the by-pass in the embodiment illustrated—used in a room unit—enters a mixing chamber *R*, from which it continues through the grille *S*.—*March* 19, 1958.



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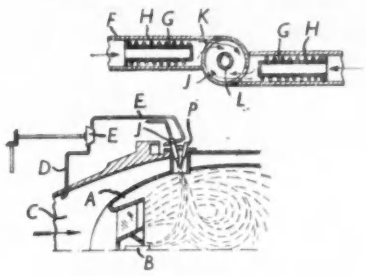
INTERNAL COMBUSTION ENGINES

791,990. March 19, 1956.—IGNITION DEVICES FOR COMBUSTION CHAMBERS, Societe Nationale d'Etude et de Construction de Moteurs d'Aviation, 150, Boulevard Haussmann, Paris, France. (*Inventor Raymond Pierre Alfred Lamouche*, 77, *rue d'Auteuil, Paris.*)

The invention relates to an ignition device for the combustion chambers of engines and propulsion units, which enables these chambers to be ignited and reignited rapidly during flight at high altitude. In the design shown in the drawing, it has been assumed that the problem consists of igniting or reigniting the main combustion chamber of a turbo-jet or a turbo-propulsion unit, the flame tube of which is shown at *A*, and the main fuel injector at *B*. The flame tube receives through the conduit *C* air supplied by the main compressor at its delivery pressure. A conduit *D* fitted to the delivery of the compressor supplies a small compressor *E*, which is driven by a power take-off, and which gives a delivery pressure twice or three times that of the conduit pressure. The flow passing through this auxiliary compressor is only a very small fraction of that of the main compressor. The highly compressed air passes through conduits *F* clearly shown in the upper view to the interior of tubes *G* of refractory material provided with holes at their periphery, and each carrying a heating resistance *H*. Each tube is followed by a carburation chamber *J* of circular cross section, with its axis at right angles to that of the tubes. The air, which passes out through the holes in the tubes, is heated to about 200 deg. Cent. and it passes into the chamber *J* tangentially through orifices *K*. Before passing through an axial nozzle in the end of the chamber towards the combustion chamber to be ignited, the air is given a vortex turbulent movement against the wall of the chamber *J*. Along its axis this chamber is provided with a porous metal sleeve *L*,



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which is supplied with kerosene delivered at a suitable pressure by a pump to the inlet, so that the kerosene forms small drops on the external surface of the sleeve *L*. The kerosene is vaporised by the hot air whirling around the sleeve and the air ejected through the nozzle is thus carburetted and passes out in the form of a highly concentrated jet at high speed. It will be seen from the lower drawing that the carburation chamber *J* may be installed on the external casing of a combustion chamber, the air passing out of the orifice being protected by a sleeve against the action of the air flowing in the space between the flame tube *A* and the external wall. The jet of carburetted air discharged into the flame tube can penetrate far into the tube by virtue of its high pressure. In the sleeve there is an ignition plug *P* with an extended rod of refractory electrical resisting metal, which is brought to a high temperature at the desired moment. The rod comes into contact with the carburetted jet passing out of the orifice, and ignites it. There is finally obtained a tongue of flame having a high penetration which quickly heats up the interior of the combustion chamber and causes the main fuel injector *B* to ignite.—*March* 19, 1958.

METALLURGY

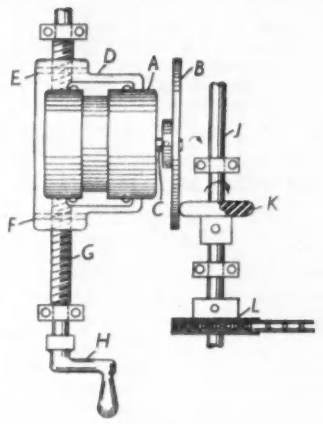
792,160. December 16, 1955.—THE DEGASIFICATION OF MOLTEN STEELS, Bochumes Verein für Gussstahlfabrikation Aktiengesellschaft, formerly Gussstahlwerk Bochumer Verein Aktiengesellschaft, Bochum, Germany.

According to the invention there is provided a process for the degasification of a steel which has been melted without the use of a vacuum and is in a condition ready for casting, but is at a higher temperature than a casting temperature generally employed. A stream of molten metal is allowed to fall freely through a vacuum chamber and divide up into individual droplets of 10mm to 10^{-3}mm diameter, such division being effected by controlling the vacuum in the vacuum chamber to maintain it within the range of from 30mm to 0·1mm Hg. This is effected by controlling the rate of feed of the stream by an inlet into the vacuum chamber which is between 25mm and 70mm in diameter, and by maintaining the ferrostatic pressure of the liquid column of the stream above the inlet into the vacuum chamber at at least 300mm in height. Present results obtained from practical tests indicate that when a droplet size of 10mm diameter is exceeded, diffusion of the gases in the molten flow is hindered to a great extent, whilst if the droplet size falls considerably below 10^{-3}mm diameter the surface tension becomes so considerable as to render impossible any practically effective gas dissipation. In the case of steel qualities which generally have a high gas content, such as unkilled steel, the pressure values of the upper part of the range indicated above are preferred. A steel which is rich in gas should be poured from a large inlet opening, but a steel poor in gas from a smaller inlet opening. In this way it is possible to effect degasification of steels in a short period.—*March* 19, 1958.

POWER TRANSMISSION

792,078. August 10, 1956.—VARIABLE-SPEED DRIVE MECHANISM, General Aniline and Film Corporation, 230, Park Avenue, New York, New York, U.S.A.

The invention relates to power transmitting mechanisms and more particularly to friction disc variable-speed drives. The principal feature of the invention is that the frictional contact between the disc and the wheel is automatically increased as the load increases and the power transfer becomes greater, and it requires no springs or other means for maintaining contact between the driving and the driven elements. Referring to the drawing, the drive motor *A* has a friction disc *B* attached to the shaft *C*. The motor is mounted on a platform bracket *D*, which has lugs *E* and *F* which accommodate the lead screw *G* journalled in bearings as shown and equipped with a handle *H*. The driven element comprises the shaft *J* parallel with the lead screw. Affixed to the shaft is the driven wheel *K*, at the end of which there is shown a power transfer sprocket *L* carrying a chain. As shown, the motor is free to pivot in a direction perpendicular to the shaft *J* on the lead screw *G* so that the weight of the motor will establish contact between the disc *B* and the driven wheel *K*. Turning the handle *H* will cause the motor to move in a direction axial to the shaft *J*, whereby the contact between disc and the wheel may be located anywhere from the centre of the



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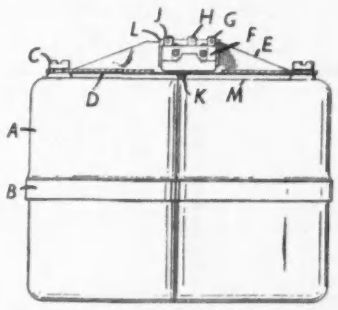
disc to the periphery in order to control the speed of the driven wheel. The direction of rotation of the disc *B*, as indicated by the arrow, is so chosen that the rotation of the driven wheel is in the direction of the pivotal movement of the motor *A*. Under such conditions, as the load on the chain increases, a force is produced between the disc *B* and the wheel *K* due to the rotational movement which will tend to move the motor down in the direction of its pivotal swing. This force thereby increases the frictional contact between the driving and driven elements. Under no-load conditions, the motor may assume a position at a small angle above the horizontal. As the load increases, the disc *B* will tend to ride on the wheel *K*, forcing itself down and thereby increasing the frictional hold. When the load decreases, the elasticity of the wheel will restore the motor *C* to normal position.—*March* 19, 1958.

ELECTRICAL ENGINEERING

791,985. February 9, 1955.—ELECTRIC TRANSFORMERS, Parmeko, Ltd., Parmeko Works, Percy Road, Aylestone Park, Leicester. (*Inventors: Samuel Neville Shaw Mee and Frederick John Toone.*)

The invention has reference particularly to transformers in which the core and the primary and secondary windings are enclosed in a hermetically sealed container. In the arrangement illustrated in the drawing the container of the transformer *A* is made



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in two deformable halves, the upper of which has a skirt *B* which overlaps the lower half, with a soldered seam. The safety device is mounted on the upper half of the transformer container by means of bolts *C*. It comprises a flat strip base *D* and two upstanding side cheeks *E* of truncated triangular form. These cheeks support between them a microswitch *F* with a body in the form of a block of insulating material. Upstanding from the upper edge of the housing *F* are three terminals—terminal *G*, for connection to a main supply, terminal *H* which is connected to the primary of the transformer passing through the wall of the container, and a ground terminal *J*. The

terminal *G* is connected, inside the switch, to a fixed contact with which a movable contact, carried by a resilient blade, co-operates, this movable contact being connected to the terminal *H*. The switch further contains a movable plunger for operating the blade carrying the movable contact, in known fashion, this plunger having a nose *K* of hard plastic material projecting through the bottom of the housing *F*. To enable the switch *F* to be raised or lowered relatively to the upper face of the container, i.e. to enable the rise in pressure which is necessary to operate the switch to be varied, the bolts can be adjusted in slots *L* in the side cheeks *E* before being tightened up. An insulating plate is sandwiched between each side of the switch housing *F* and the corresponding side cheek *E* to shield the terminals. Thus, in use, a rise in pressure to an impermissible degree in the container housing will result in the bowing of the face *M* and this will be used to operate the plunger *K* and thus interrupt the current supply to the primary of the transformer. In view of the very sensitive nature of the switch, and the provision for adjustable mounting, the pressure rise can be regulated within very sensitive limits.—*March* 19, 1958.

Launches and Trial Trips

PORT INVERCARGILL, cargo liner; built at Belfast by Harland and Wolff, Ltd., for the Port Line, Ltd.; length between perpendiculars 460ft, breadth moulded 65ft 6in, depth moulded 41ft 6in, gross tonnage 9000; five cargo holds, one 70-ton, four 15-ton, four 10-ton and six 5-ton derricks and one 3-ton electric crane; three 360kW diesel-driven generators; Harland and Wolff opposed-piston, two-stroke, single-acting diesel engine, seven cylinders, 750mm diameter by 2000mm combined stroke. Launch, November 22.

REIN, oil tanker, built by the Netherland Dock and Shipbuilding Company, for Skips A/S Polarfront, Norway; length 213·5m, breadth 28·5m, deadweight 39,000 tons on 11·04m draught; four 1250 tons per hour turbine-driven pumps, three 150 tons per hour stripping pumps; three 550kVA, 60 c/s, turbo-alternators, one 220kVA, diesel-driven alternator, one set of N.D.S.M.-Parsons two-stage geared turbines, 17,500 normal s.h.p. at 98 propeller r.p.m., two Babcock and Wilcox boilers supply steam at 600 lb per square inch, 800 deg. Fah. Trial, November 22.

TEMPLE MAIN, closed shelter deck cargo liner; built by The Caledon Shipbuilding and Engineering Company, Ltd., for the Temple Steamship Company, Ltd.; length overall 457ft, breadth moulded 58ft 6in, depth moulded to shelter deck 37ft 9in; five holds, one 50-ton, six 10-ton and six 5-ton derricks, three bi-pod masts, electric deck machinery; three 200kW diesel-driven generators; Vickers-Doxford oil engine, 3600 b.h.p. Launch, November 22.

CITY OF GUILDFORD, cargo liner; built at Wallsend by Swan, Hunter and Wigham Richardson, Ltd., for Ellerman Lines, Ltd.; length between perpendiculars 405ft, breadth moulded 59ft, depth moulded to shelter deck 36ft 9in, load draught 24ft 6in, deadweight 7760 tons on 24ft 7½in draught, service speed 14½ knots; four cargo holds, four deep tanks, derricks to lift 7 tons or 10 tons, electric winches; three 180kW diesel-driven generators; Clark-Sulzer single-acting, two-stroke diesel engine, eight cylinders, 720mm diameter by 1250mm stroke, 5040 b.h.p. at 121 r.p.m. Trial, November 28.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office not later than a fortnight before the meeting. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS

Sat., April 19.—OXFORD, READING AND DISTRICTS BRANCH: Collier Lecture Room, Regent's Park College, Pusey Street, Oxford, "The Building of the Berkeley Atomic Power Station," 7 p.m.
Mon., April 21.—LONDON NATIONAL LECTURE: Lecture Theatre, Institution of Electrical Engineers, Savoy Place, London, W.C.2, Discussion on "Maintenance and Installation Problems," 6.30 p.m.
Thurs., April 24.—SOUTH LONDON BRANCH: Greyhound Hotel, High Street, Croydon, "Earth Leakage Protection of Domestic and Industrial Installations," J. A. Robbins, 8 p.m.

BRITISH COMPUTER SOCIETY

Mon., April 21.—York Hall, Caxton Hall, Westminster, London, S.W.1, "The Use of an Electronic Computer in Research Statistics: Four Years' Experience," F. Yates, 6.15 p.m.

BRITISH INSTITUTION OF RADIO ENGINEERS

Wed., April 23.—LONDON SECTION: London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1, "Measurement of the Frequency Response of a Nuclear Reactor," R. J. Cox, D. Harrison and B. B. Stevens, 6.30 p.m.
Fri., April 25.—SOUTH MIDLANDS SECTION: North Gloucestershire Technical College, Cheltenham, "The Automatic Factory," J. A. Sargrove, 7 p.m.

COMBUSTION ENGINEERING ASSOCIATION

Wed., April 23.—MIDLAND REGION: Birmingham Exchange and Engineering Centre, Birmingham, Films, "Conveyors Your Servants" and "The Seed is Sown," W. G. Picton, 10.30 a.m.; "Industrial Use of Coke," E. Murphy and A. S. Boyle, 2.30 p.m.

ILLUMINATING ENGINEERING SOCIETY

Mon., April 21.—BATH AND BRISTOL CENTRE: South Western Electricity Board, Bath, Annual General Meeting, 7 p.m. ★ LEICESTER CENTRE: Bell Hotel, Leicester, Annual General Meeting, 7 p.m.
Fri., April 25.—BIRMINGHAM CENTRE: Regent House, St. Phillip's Place, Colmore Row, Birmingham, "Light and Colour," 6 p.m.

INCORPORATED PLANT ENGINEERS

Tues., April 22.—BIRMINGHAM BRANCH: Hotel Leofric, Coventry, Film, "Taking the Load," 7.30 p.m. ★ SOUTH WALES BRANCH: South Wales Engineers' Institute, Park Place, Cardiff, "Effects of Steam Peaks," E. G. Ritchie, 7.15 p.m.
Thurs., April 24.—SHEFFIELD AND DISTRICT BRANCH: Grand Hotel, Sheffield, "Factory Services and Supplies, with Particular Reference to Gas Requirements and Installation," F. Dickinson, 7.30 p.m.
Fri., April 25.—BIRMINGHAM BRANCH: Imperial Hotel, Temple Street, Birmingham, Film, "Hydraulic Power at Rawden Colliery," 7.30 p.m.
Mon., April 28.—WEST AND EAST YORKSHIRE BRANCH: The University, Leeds, "The Raising of the Hoenfells," A. T. Bride, 7.30 p.m.

INSTITUTE OF BRITISH FOUNDRYMEN

Wed., April 23.—LONDON BRANCH: Constitutional Club, Northumberland Avenue, London, W.C.2, Annual General Meeting; Short Paper Competition, 7 p.m. ★ SOUTHAMPTON SECTION: Technical College, St. Mary's Street, Southampton, Annual General Meeting; Film, "Modern Malleable," 7.30 p.m.

INSTITUTE OF FUEL

Wed., April 23.—LONDON BRANCH: Institution of Civil Engineers, Great George Street, London, S.W.1, Presidential Address, H. McNeil, 6.30 p.m.
Thurs., April 24.—LONDON BRANCH: Connaught Rooms, Great Queen Street, Kingsway, London, W.C.2, Annual General Meeting, 11.30 a.m.

INSTITUTE OF MARINE ENGINEERS

Tues., April 22.—Memorial Building, 76, Mark Lane, London, E.C.3, Annual General Meeting, 5.30 p.m.
Thurs., April 24.—Memorial Building, 76, Mark Lane, London, E.C.3, Discussion on "Marine Machinery Breakdowns," introduced by J. H. Milton, 5.30 p.m.

INSTITUTE OF NAVIGATION

Fri., April 25.—Royal Geographical Society, 1, Kensington Gore, London, S.W.7, "The Use of Simulators for Training Navigators to Use Radar Equipment," 5.15 p.m.

INSTITUTE OF ROAD TRANSPORT ENGINEERS

Mon., April 21.—SCOTTISH CENTRE: Institution of Engineers and Shipbuilders, Elmbank Crescent, Glasgow, Annual General Meeting, 7.30 p.m.
Tues., April 22.—NORTH EASTERN CENTRE: Three Tuns Hotel, Durham City, Annual General Meeting, 7 p.m.
Fri., April 25.—SOUTHERN CENTRE: Palmeira Hotel, 71, Cromwell Road, Hove, Sussex, Annual General Meeting, 7.30 p.m.

INSTITUTION OF CHEMICAL ENGINEERS

Thurs., April 24.—NORTH WESTERN BRANCH: Reynolds Hall, College of Science and Technology, Manchester, Joint Meeting with Northern Branch of the Institute of Petroleum, "Modern Processes in Petroleum Refining," 7 p.m.

INSTITUTION OF CIVIL ENGINEERS

Tues., April 22.—Great George Street, London, S.W.1, "Hydrology and Water Development in Cyprus," I. L. Ward, D. P. McGregor and M. Grehan, 5.30 p.m.
Mon., April 28.—MIDLANDS ASSOCIATION: Visit to the Cement Marketing Company, Cauldon Low, Near Leek, Staffordshire, 10.15 a.m.

INSTITUTION OF ELECTRICAL ENGINEERS

To-day, April 18.—SOUTH MIDLAND CENTRE: College of Technology, Gosta Green, Birmingham, "Training for the Electrical Trades," R. W. G. Ward, 6.15 p.m.
Mon., April 21.—WESTERN SUPPLY GROUP: South Wales Electricity Board, Demonstration Theatre, Electricity House, Colston Avenue, Bristol, "My Visit to the U.S.A.," J. S. Lombard, 6 p.m.
Tues., April 22.—CAMBRIDGE RADIO AND TELECOMMUNICATION GROUP: Cavendish Laboratory, Free School Lane, Cambridge, "Underwater Television," D. Allanson, 8 p.m. ★ SOUTH WEST SCOTLAND SUB-CENTRE: Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, C.2, "Operational Experience—Calder Hall," K. L. Stretch, 7 p.m.
Wed., April 23.—RUGBY SUB-CENTRE: Wyncotts Café, Banbury, "Recent Developments in Mains Frequency Induction Heating and Melting," E. May, 6.30 p.m. ★ LONDON GRADUATE AND STUDENT SECTION: Visit to Central Electricity Authority Research Laboratories, Leatherhead, 2 p.m. ★ RADIO AND TELECOMMUNICATION SECTION: Savoy Place, London, W.C.2, "Survey of Performance Criteria and Design Considerations in High-Quality Monitoring Loudspeakers," D. E. L. Shorter, 5.30 p.m.
Thurs., April 24.—ORDINARY MEETING: Savoy Place, London, W.C.2, "The Generation of Electricity in the London Area," H. V. Pugh, 5.30 p.m.
Mon., April 28.—RADIO AND TELECOMMUNICATION SECTION: Savoy Place, London, W.C.2, "Economic Usage of Broadband Transmission Systems," R. J. Halsey, 5.30 p.m. ★ SOUTH MIDLAND RADIO AND MEASUREMENTS GROUP: James Watt Memorial Institute, Great Charles Street, Birmingham, "Servo-Operated Recording Instruments," A. J. Maddock, 6 p.m.

INSTITUTION OF ENGINEERING DESIGNERS

Thurs., April 24.—38, Portland Place, London, W.1, "Some Aspects of Weight Control in Design," J. McLaughlin and F. Howarth, 6.45 p.m.

INSTITUTION OF MECHANICAL ENGINEERS

To-day, April 18.—LONDON BRANCH: 1, Birdcage Walk, Westminster, London, S.W.1, Annual General Meeting, 6 p.m.
Mon., April 21.—MIDLAND GRADUATES' SECTION: James Watt Memorial Institute, Great Charles Street, Birmingham, Technical Film Show, 6.45 p.m.
Tues., April 22.—STEAM GROUP: 1, Birdcage Walk, Westminster, London, S.W.1, Discussion on "Availability of Power Plant," 6 p.m. ★ SOUTH WALES BRANCH: Lecture Theatre, South Wales Electricity Board's Showrooms, The Kingsway, Swansea, "Management Control of Small Engineering Firms," L. Fontaine, W. R. Spencer and J. W. Walker, 6 p.m. ★ NORTH WESTERN GRADUATES' SECTION: Engineers' Club, Albert Square, Manchester, Annual Meeting, "Installation and Maintenance of Air Compressors and Ancillary Equipment," W. R. MacMillan, 7 p.m.
Wed., April 23.—EDUCATION GROUP: 1, Birdcage Walk, Westminster, London, S.W.1, Discussion on "Teaching the Fundamentals of Automatic Control," 6 p.m. ★ YORKSHIRE GRADUATES' SECTION: Visit to Slazengers, Ltd., Horbury, Wakefield, 7 p.m.
Thurs., April 24.—SCOTTISH BRANCH: Visit to Goodyear Tyres, Ltd., Knightswood, Glasgow, 7 p.m. ★ WESTERN A.D. CENTRE: Royal Hotel, Bristol, "Inspection of Vehicles for Road Worthiness, with Special Reference to Methods and Equipment," G. Grime and R. D. Lister, 6.45 p.m. ★ EAST MIDLANDS GRADUATES' SECTION: Technical College, Lincoln, "Racing the B.R.M.," A. F. Rivers-Fletcher, 7.15 p.m. ★ LONDON GRADUATES' SECTION: 1, Birdcage Walk, Westminster, London, S.W.1, "Some Methods of Manufacture and Applications of Flexible Metallic Tubing," C. Bateman, 6.30 p.m.
Fri., April 25.—LONDON BRANCH: 1, Birdcage Walk, Westminster, London, S.W.1, "First Year of Operation of a Cyclone-Fired Boiler," R. P. McCulloch, J. R. Willetts and A. Richardson, 6 p.m. ★ LONDON GRADUATES' SECTION: Visit to Associated Newspapers, Northcliffe House, London, E.C.4, 9.30 p.m.

INSTITUTION OF NAVAL ARCHITECTS AND THE INSTITUTE OF MARINE ENGINEERS

Wed., April 23.—SOUTHERN JOINT BRANCH: Royal Beach Hotel, Southsea, Symposium on "The Use of Plastics for Marine Application," 11 a.m.
Thurs., April 24.—SOUTHERN JOINT BRANCH: Civic Centre, Southampton, Symposium on "The Use of Plastics for Marine Application," 11 a.m.

INSTITUTION OF PRODUCTION ENGINEERS

To-day, April 18.—SWANSEA SECTION: Central Library, Alexandra Road, Swansea, Films, 7.30 p.m.
Sat., April 19.—WORCESTER SECTION: Visit to W. H. Allen and Co., Ltd., Atlas Works, Pershore, Worcs, 10.30 a.m.
Mon., April 21.—COVENTRY GRADUATE SECTION: Craven Arms Hotel, High Street, Coventry, Annual General Meeting; "Karakoram Himalayan Expedition, 1957," K. J. Miller, 7.15 p.m.
Thurs., April 24.—SOUTH EASTERN REGION: Royal Empire Society, Northumberland Avenue, London, W.C.2, "The Engineering Industry Since the War," M. Postan, 7 p.m.
Mon., April 28.—NORTH WESTERN REGION: Great Hall, Manchester College of Science and Technology, Sackville Street, Manchester, "Human Problems in Industry," The Rt. Rev. Dr. Greer, The Lord Bishop of Manchester, 6.30 p.m.

INSTITUTION OF THE RUBBER INDUSTRY

To-day, April 18.—NORTH EASTERN SECTION: Eldon Grill, Grey Street, Newcastle, Annual General Meeting and Dinner, 7 p.m.

INSTITUTION OF STRUCTURAL ENGINEERS

Tues., April 22.—SCOTTISH BRANCH: Institution of Engineers and Shipbuilders, 39, Elmbank Crescent, Glasgow, Annual General Meeting, 7 p.m.
Fri., April 25.—MIDLAND COUNTIES BRANCH: James Watt Memorial Institute, Great Charles Street, Birmingham, Annual General Meeting, "Model Analysis," J. W. Fortey, 6 p.m.

INSTITUTION OF WORKS MANAGERS

To-day, April 18.—NOTTS AND DERBY BRANCH: Grandstand Hotel, Nottingham Road, Derby, Annual General Meeting, 7.30 p.m.
Thurs., April 24.—DONCASTER BRANCH: Milton Room, The Danum Hotel, Doncaster, Film, "Planned for the Purpose"; Annual General Meeting, 7.30 p.m.

JUNIOR INSTITUTION OF ENGINEERS

To-day, April 18.—Pepys House, 14, Rochester Row, Westminster, London, S.W.1, "A Review of P.E.R.A. Activities," R. L. Hayward, 7 p.m.

PLASTICS INSTITUTE

To-day, April 18.—MIDLANDS SECTION: James Watt Memorial Institute, Great Charles Steeet, Birmingham, 3, "Marketing Methods," A. W. Sherwood, 6.30 p.m.
Wed., April 23.—SOUTH WALES AND MONMOUTHSHIRE SECTION: Visit to Saunders Valve Company, Ltd., 2.30 p.m.

REINFORCED CONCRETE ASSOCIATION

Wed., April 23.—11, Upper Belgrave Street, London, S.W.1, "Recent Developments in Prestressed Concrete in Belgium," D. Vandepitte, 6 p.m.

ROYAL METEOROLOGICAL SOCIETY

Wed., April 23.—49, Cromwell Road, London, S.W.7, Annual General Meeting; Presidential Address, "Transfer Across the Earth's Surface and Through the Air Above," P. A. Sheppard, 5 p.m.

ROYAL SOCIETY OF ARTS

Mon., April 21.—John Adam Street, Adelphi, London, W.C.2, "Systems and Uses of Pre-Stressed Concrete," G. W. Kirkland, 6 p.m.
Wed., April 23.—John Adam Street, Adelphi, London, W.C.2, "British Trade and Commerce," No. I, "With Latin-America." Sir John Taylor, 2.30 p.m.
Mon., April 28.—John Adam Street, Adelphi, London, W.C.2, "Applications and Examples of Prestressed Concrete Work," G. W. Kirkland, 6 p.m.

ROYAL STATISTICAL SOCIETY

Wed., April 23.—EDINBURGH GROUP: Heriot Watt College, Edinburgh, Annual General Meeting; "Errors in Choosing an Elite," 7 p.m.
Thurs., April 24.—SHEFFIELD GROUP: Y.M.C.A., 49, Fargate, Sheffield, 1, "Monte Carlo Methods," K. D. Tocher, 7 p.m.

SOUTH WALES INSTITUTE OF ENGINEERS

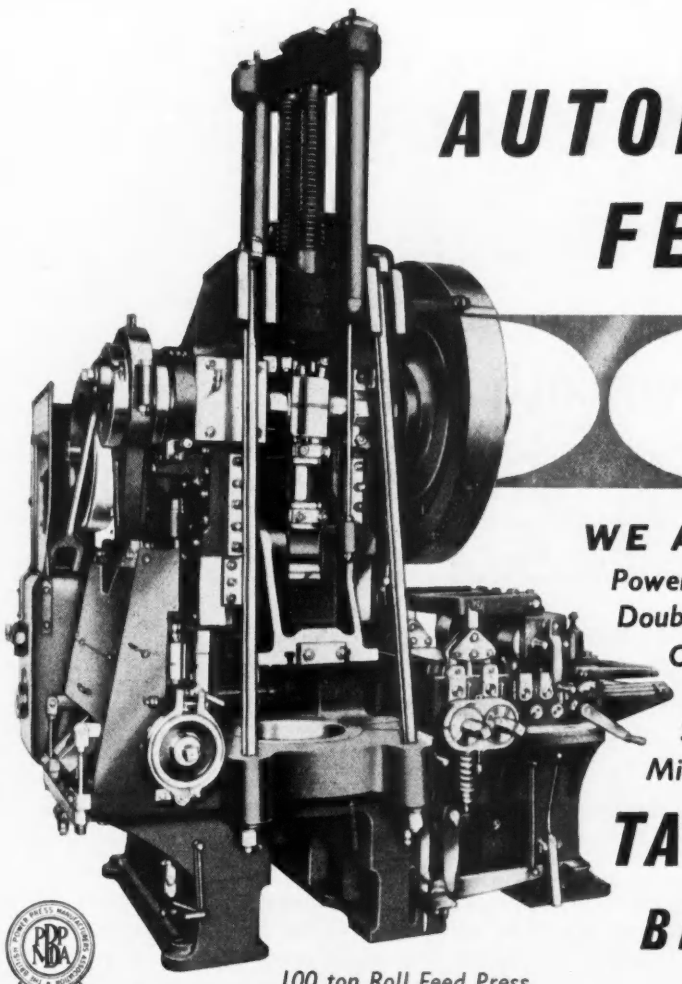
Thurs., April 24.—Park Place, Cardiff, "The Modernisation of the Western Region, British Railways," M. G. R. Smith and R. A. Smeddle, 6 p.m.

UNIVERSITY OF LONDON

Mon., April 28.—Royal College of Science (Main Chemistry Theatre), Imperial College of Science and Technology, Prince Consort Road, London, S.W.7, "Some Automata of the Eighteenth Century," H. Zemanek, 5.30 p.m.

WOMEN'S ENGINEERING SOCIETY

Mon., April 21.—Central Electricity Authority Headquarters, Winsley Street, London, W.1, "Philosophy of Guided Missile Design," P. M. Chettle, 6.45 p.m.



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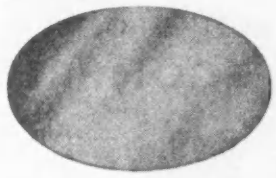

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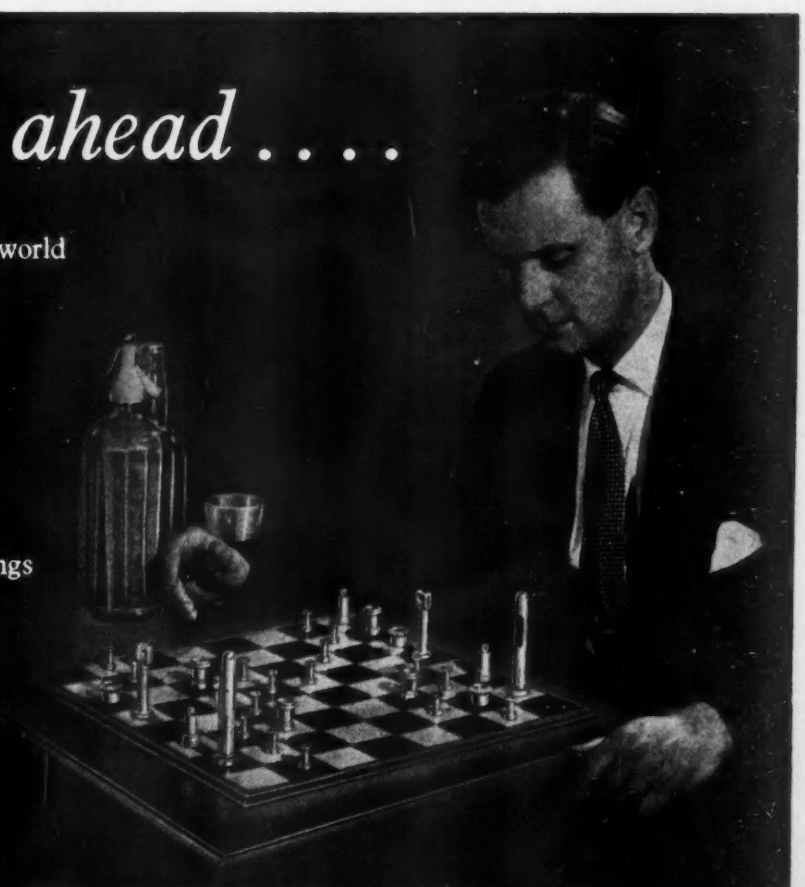

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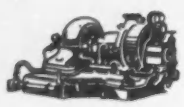

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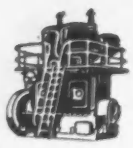

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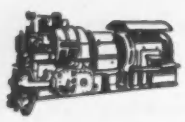

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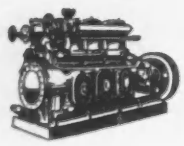

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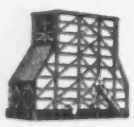

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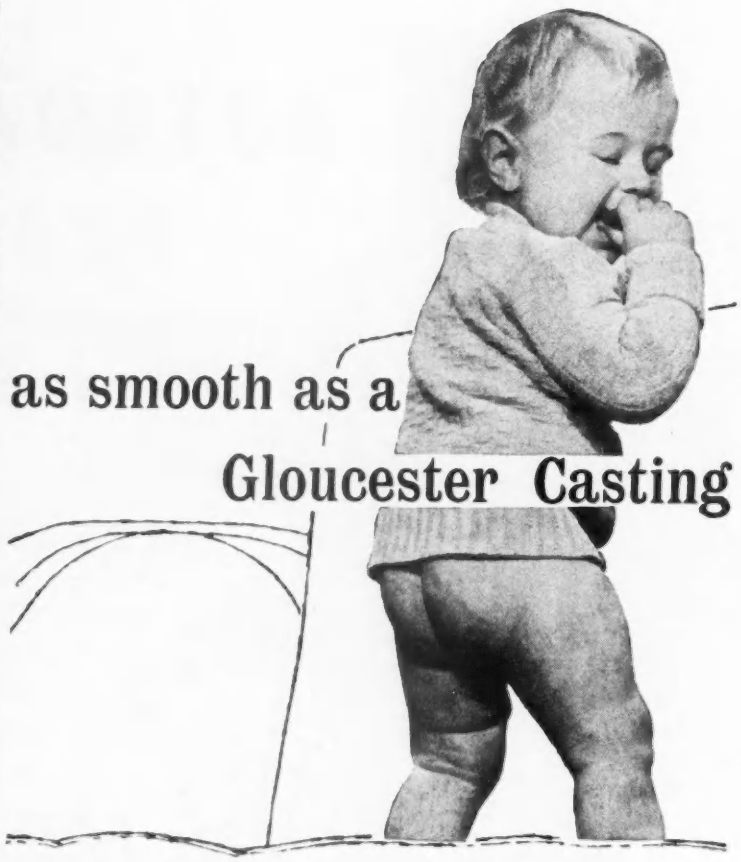

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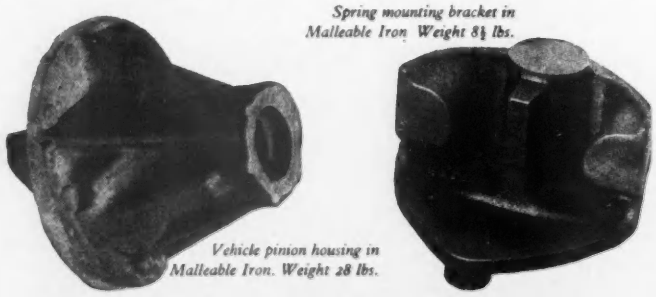

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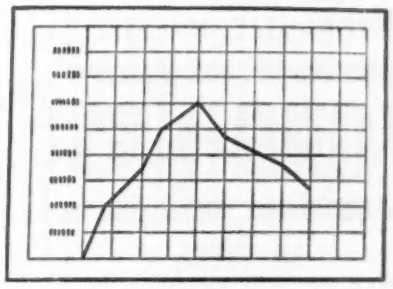

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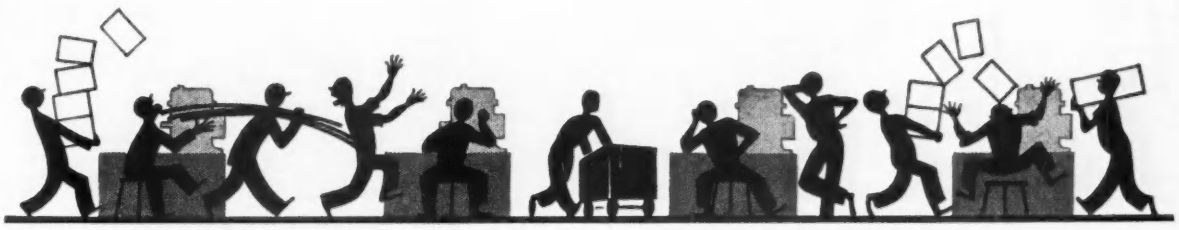

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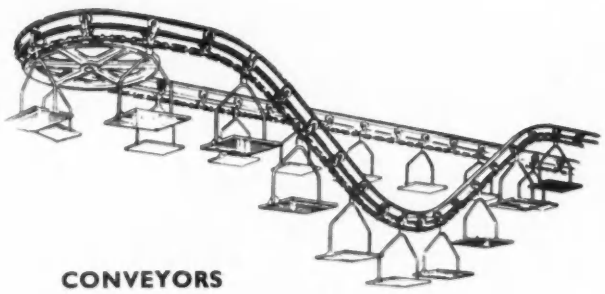

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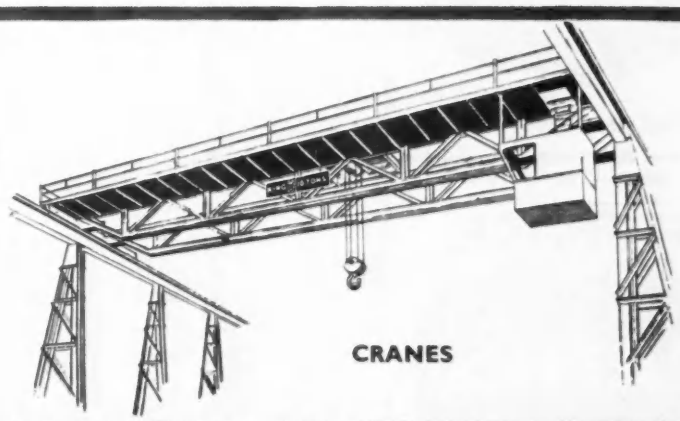

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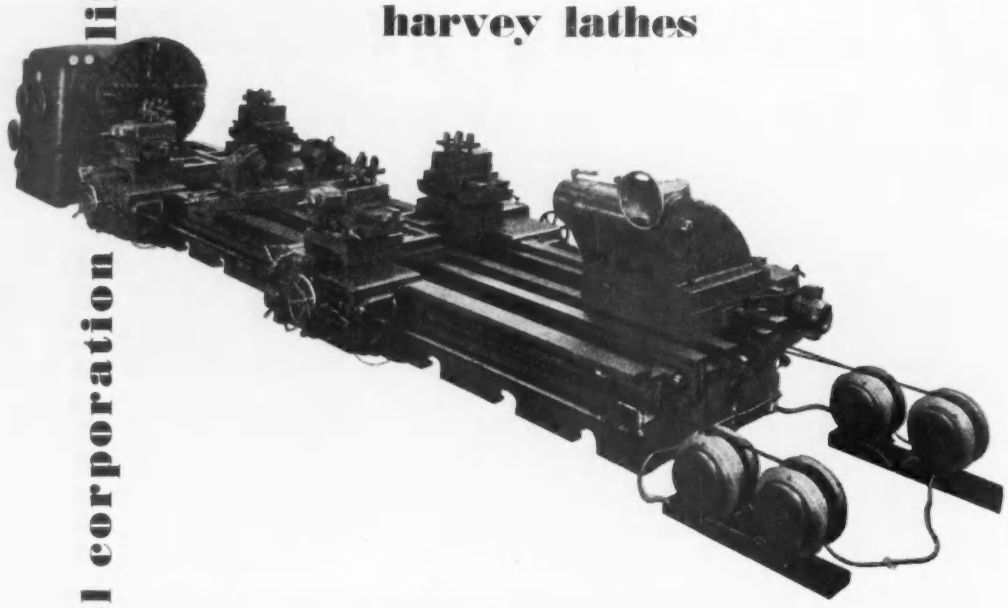

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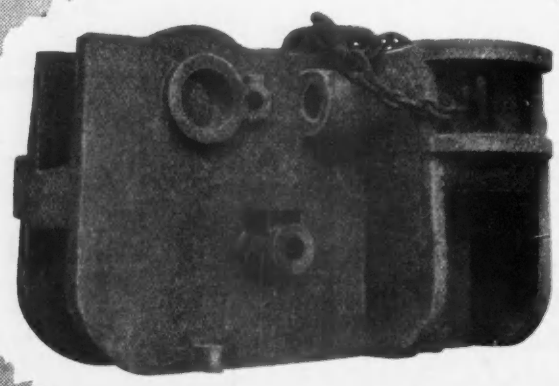

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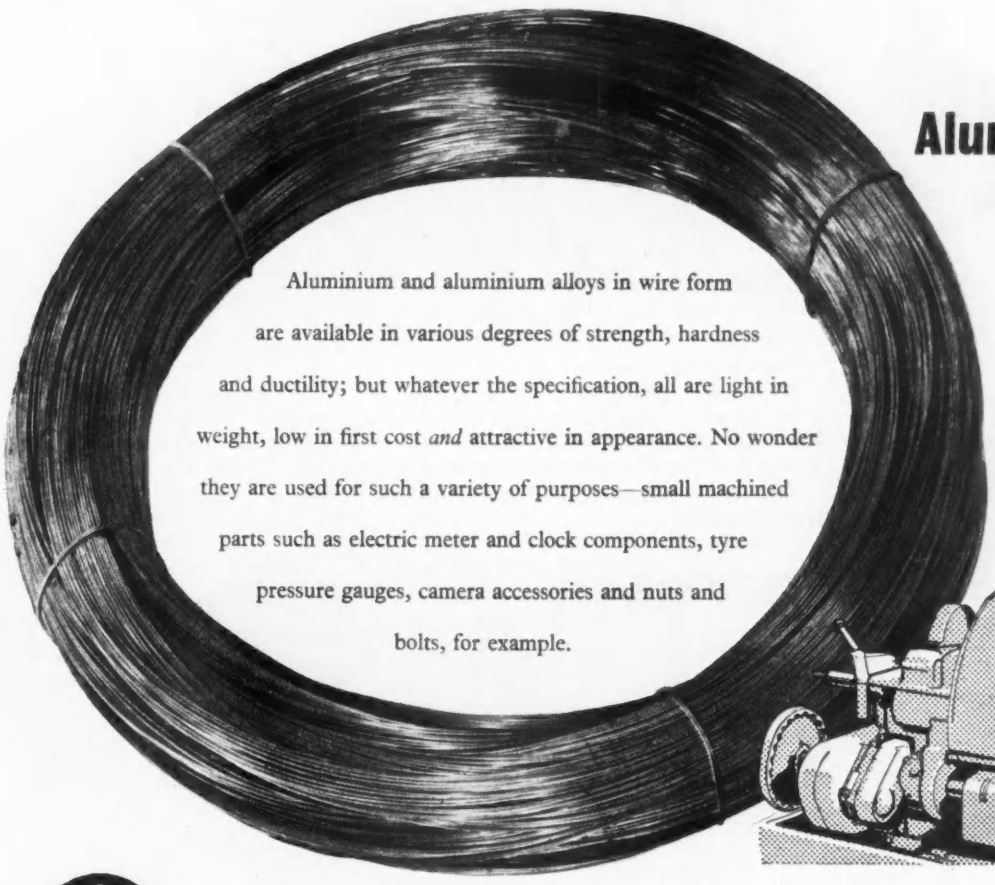

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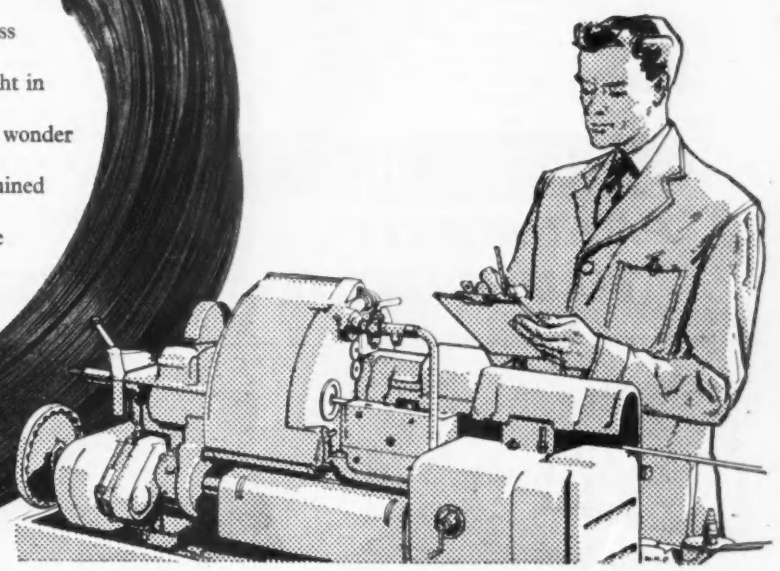

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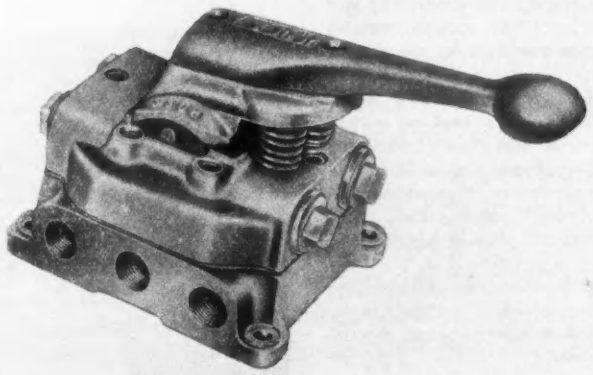

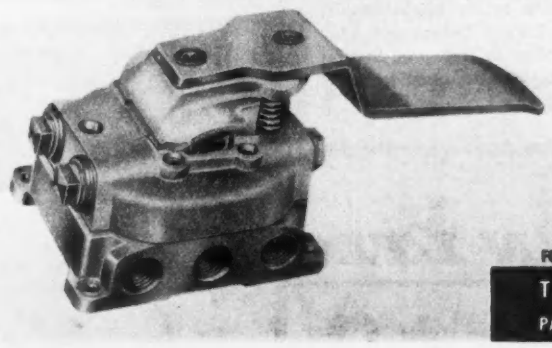

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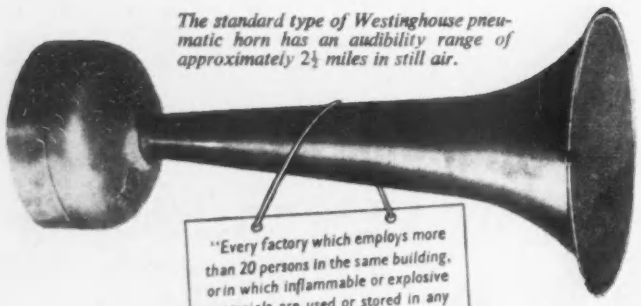

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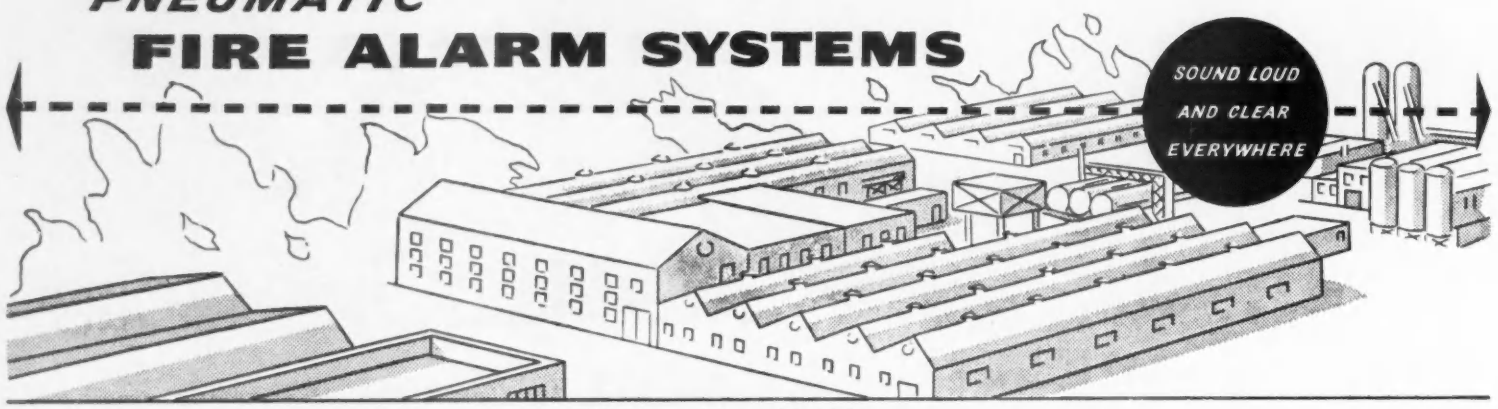

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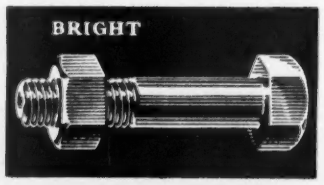

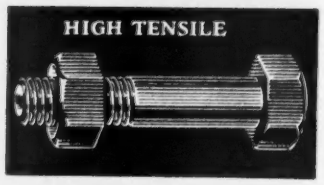

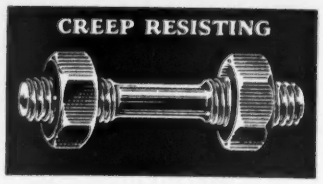

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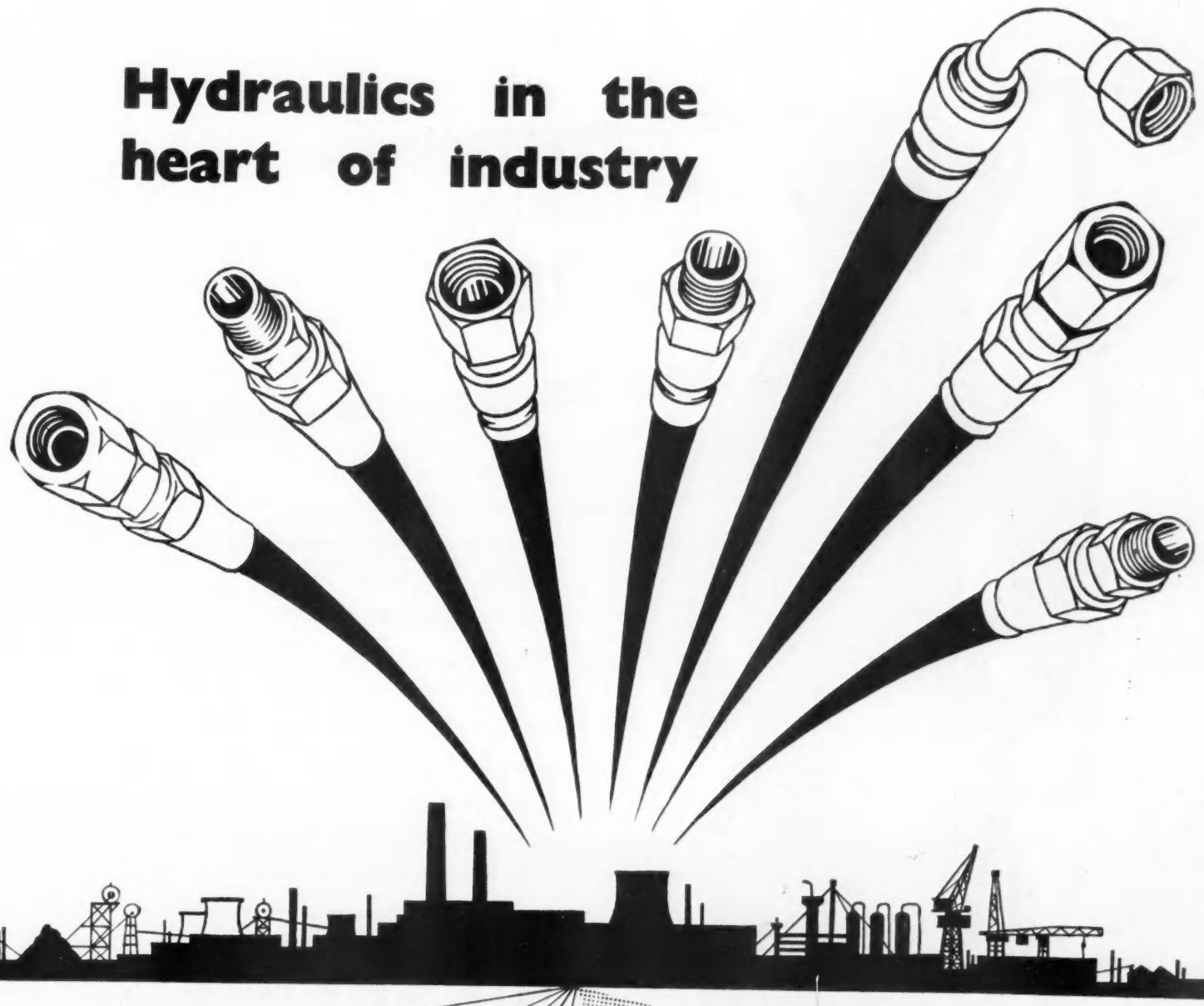

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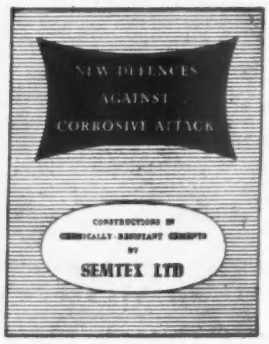

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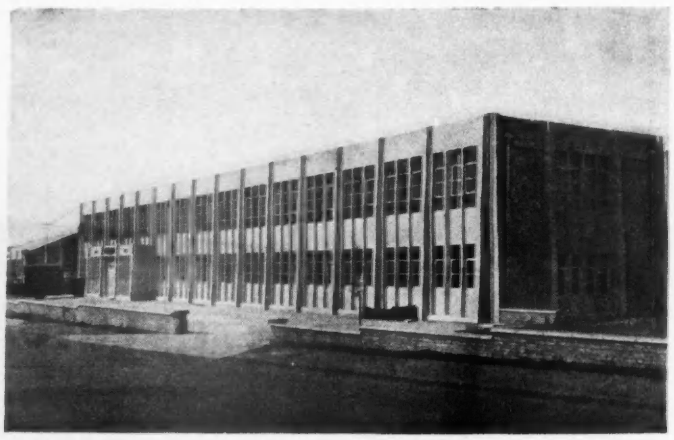
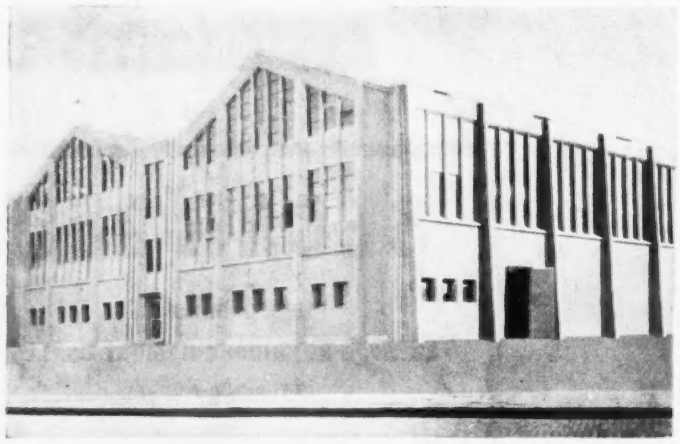


Office block for Messrs. Nortons-Tividale Ltd. Tipton, Staffs.

Interior : Central Engineering Workshop, Messrs. Bryant & May Ltd. Central Engineering Works, Old Ford Road, Bow, London, E.3.



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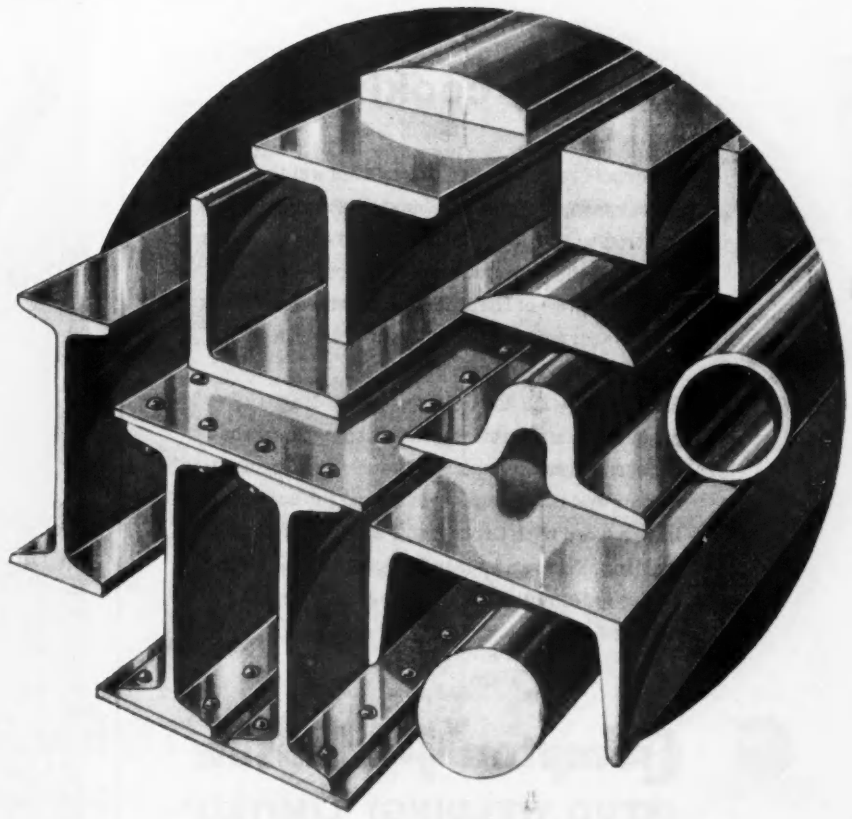

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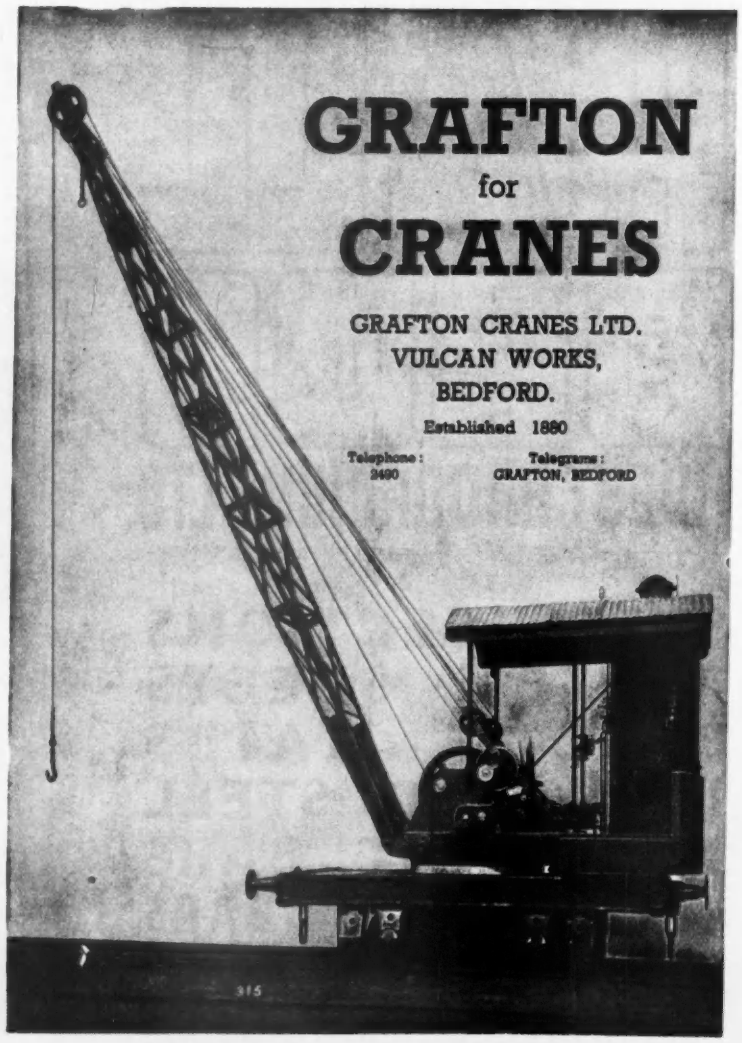

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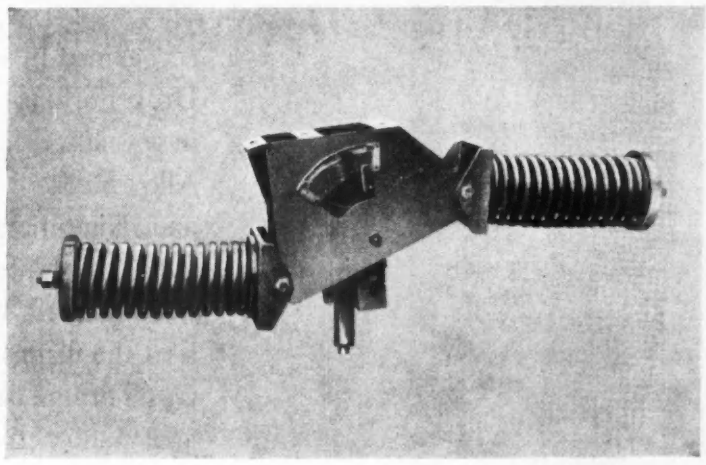

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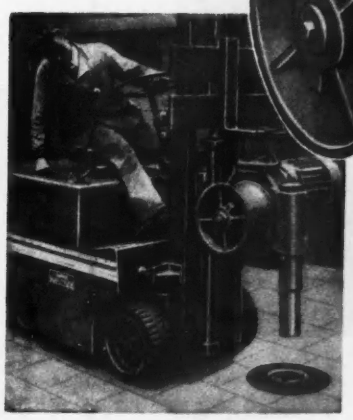

Photograph illustrates unit being lifted from ground socket by Standard Fork Truck.

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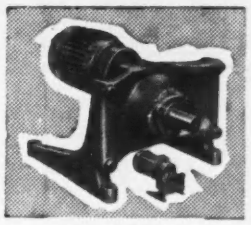

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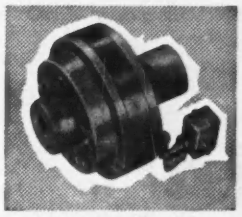

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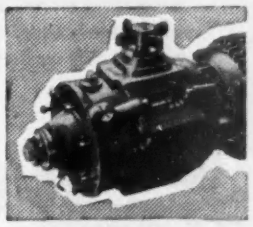

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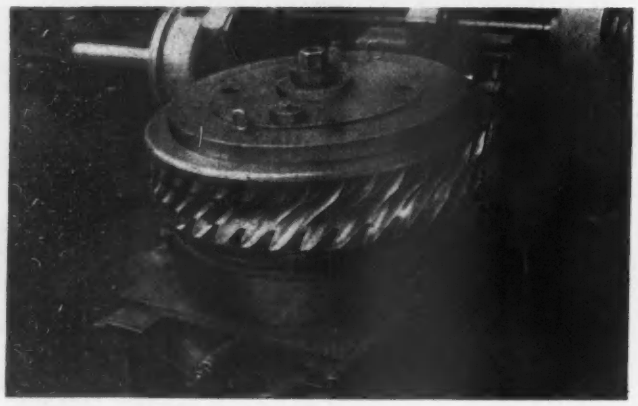

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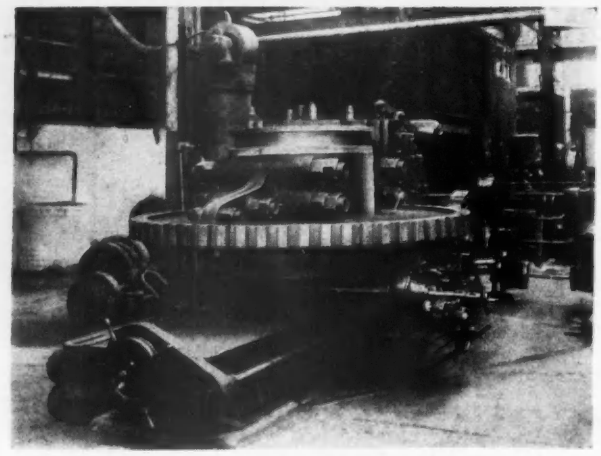

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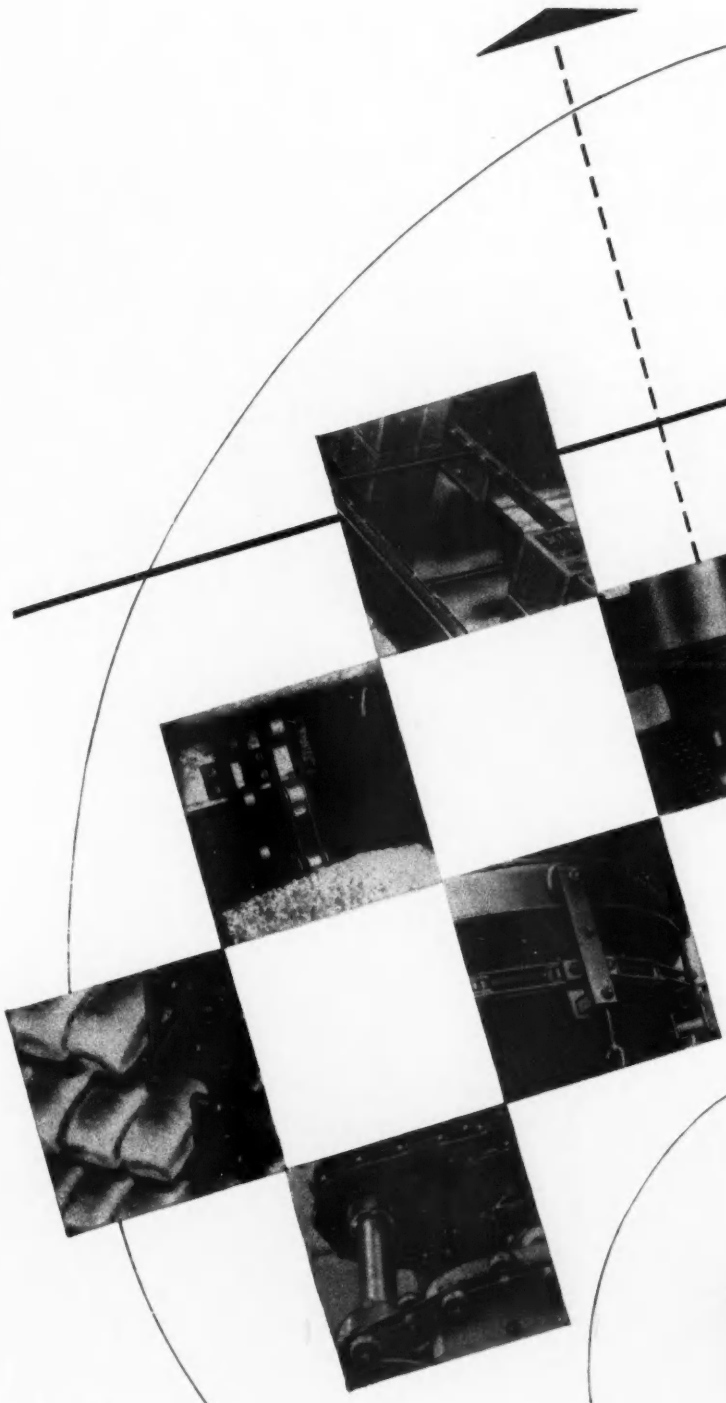

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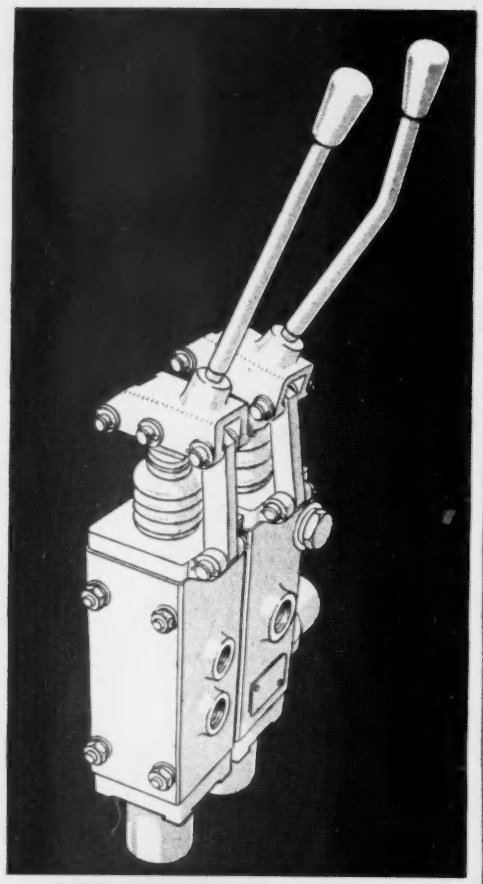

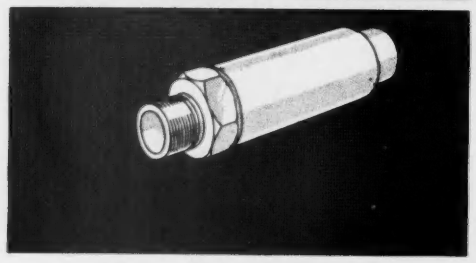

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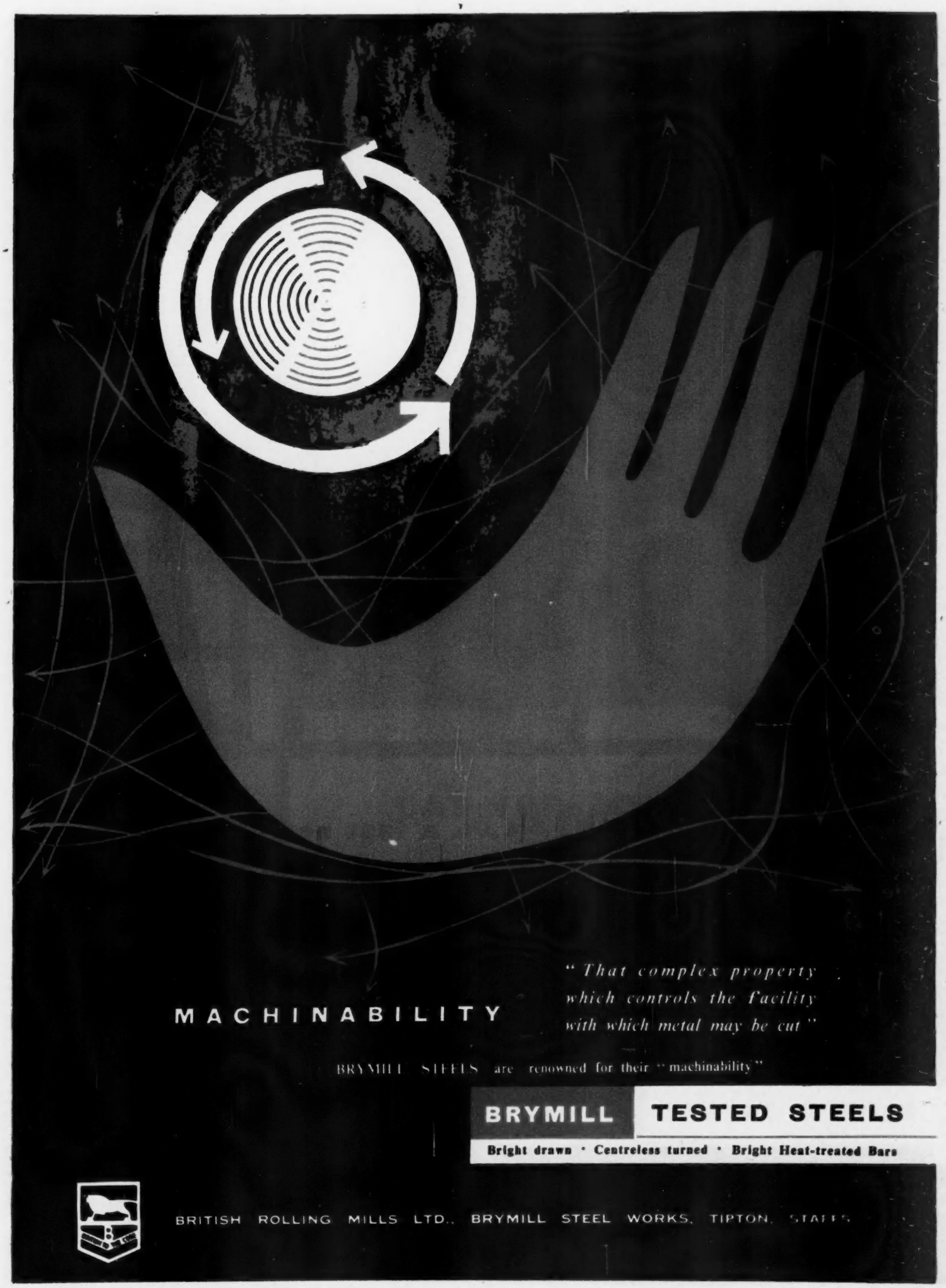
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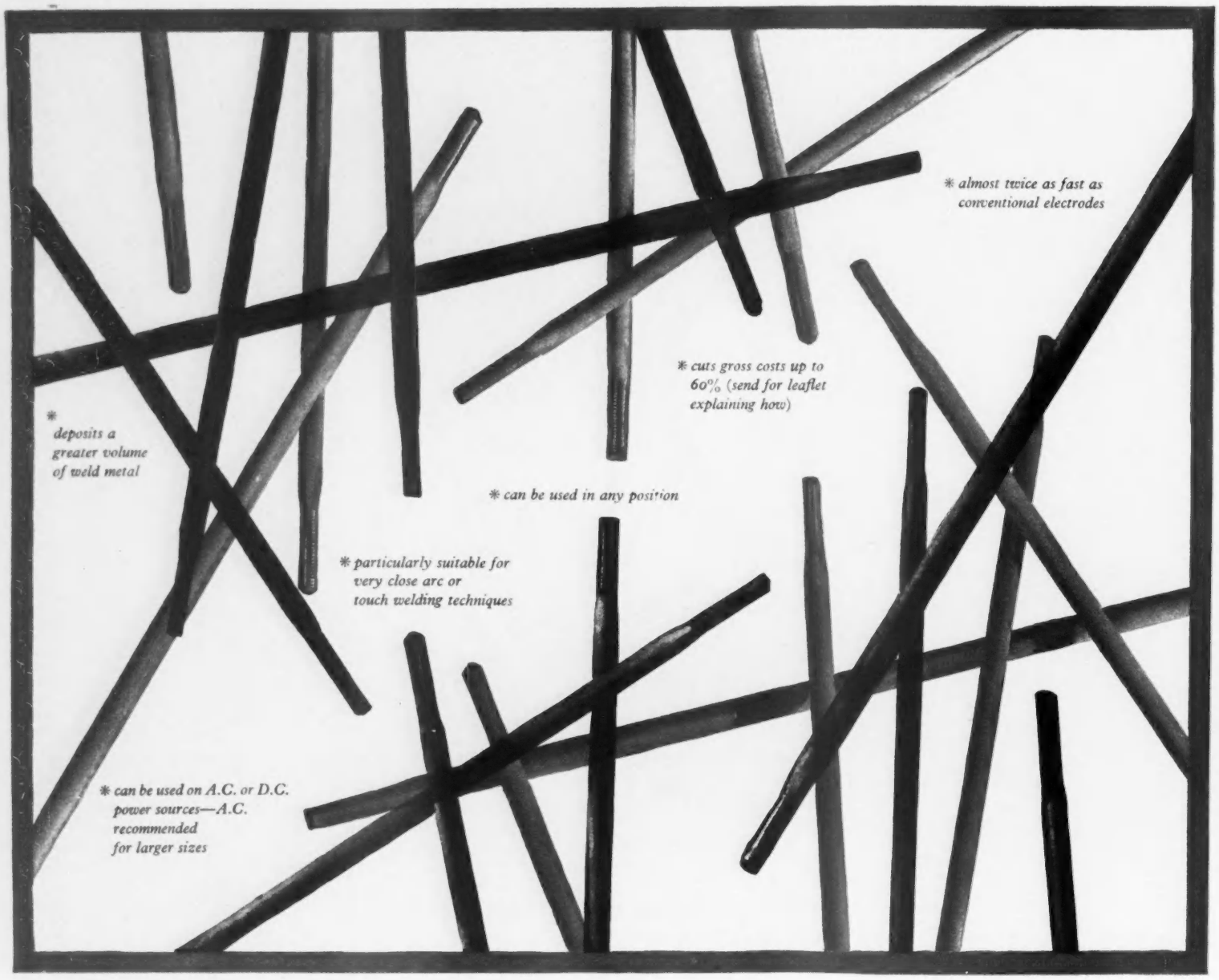
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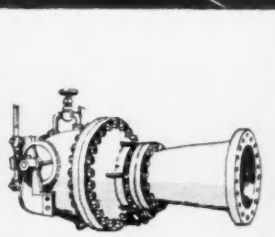
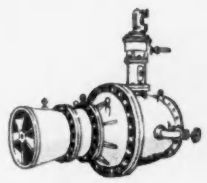
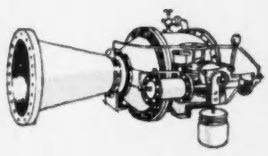


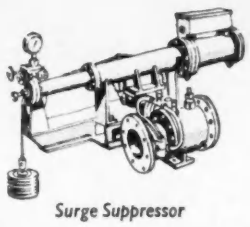
Pipeline Control Valve



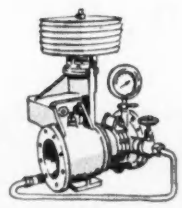
Discharge Regulator



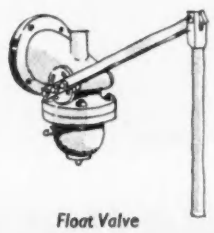
Self Closing Valve



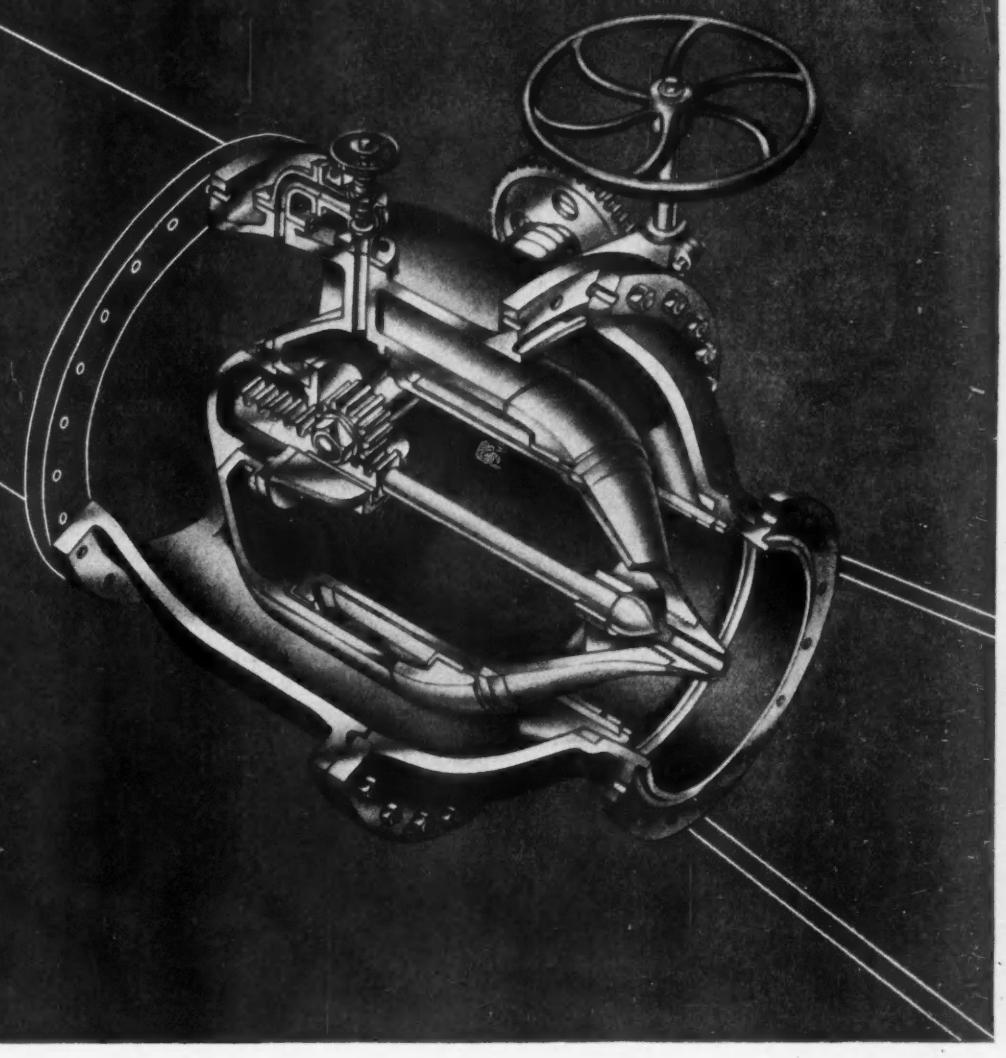
Surge Suppressor



Pressure Reducing Valve



Float Valve



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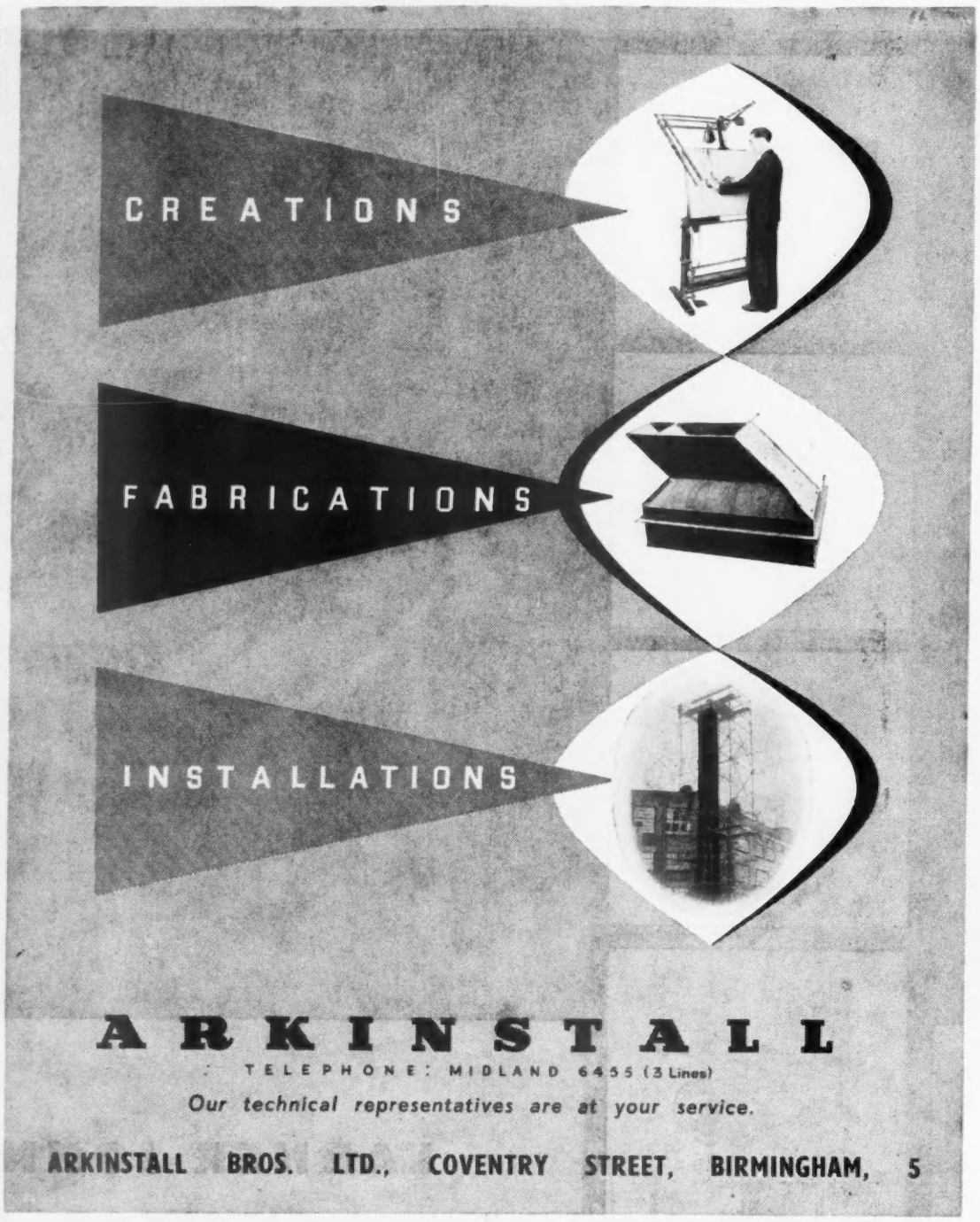

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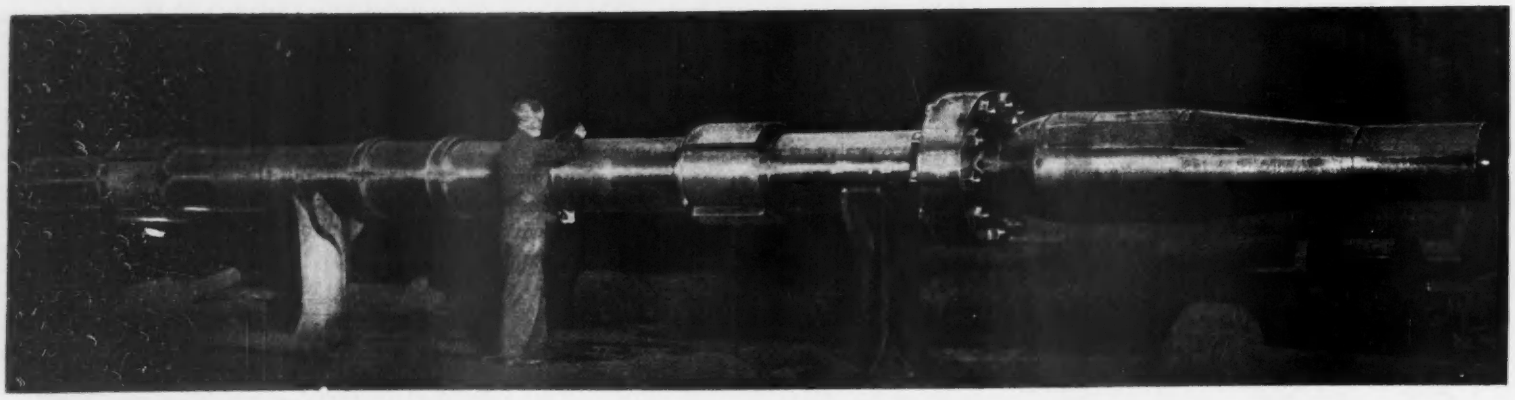

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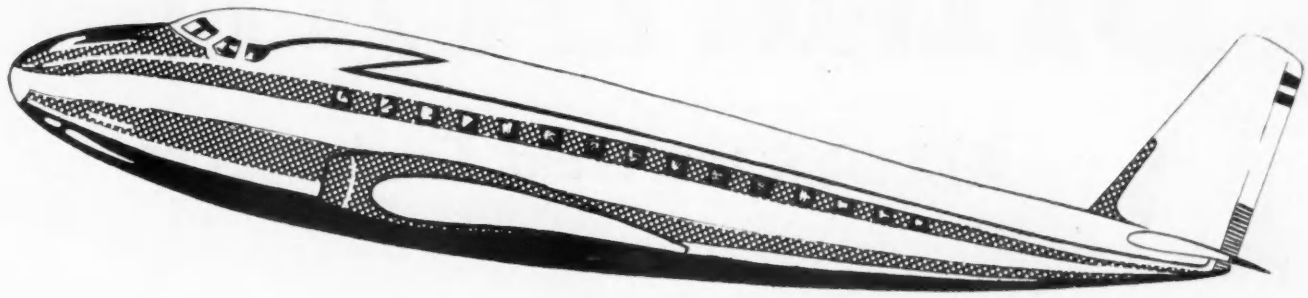

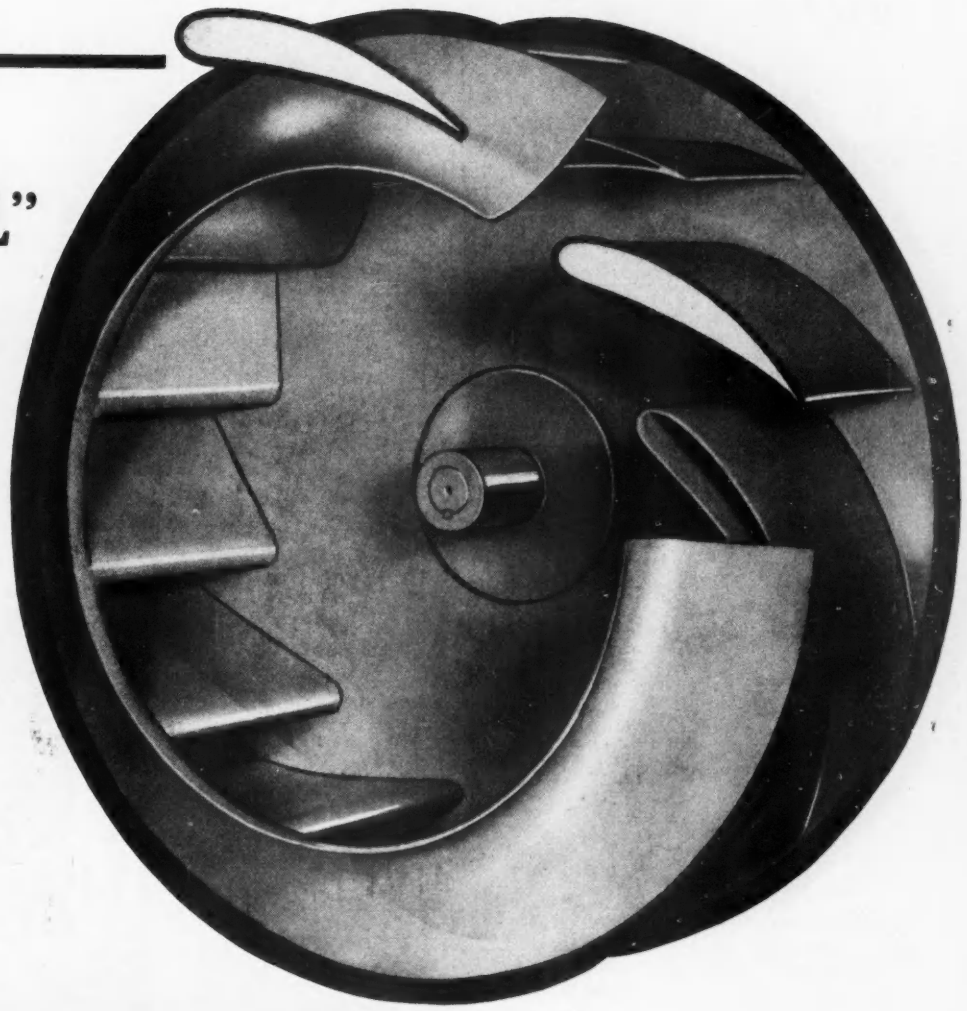

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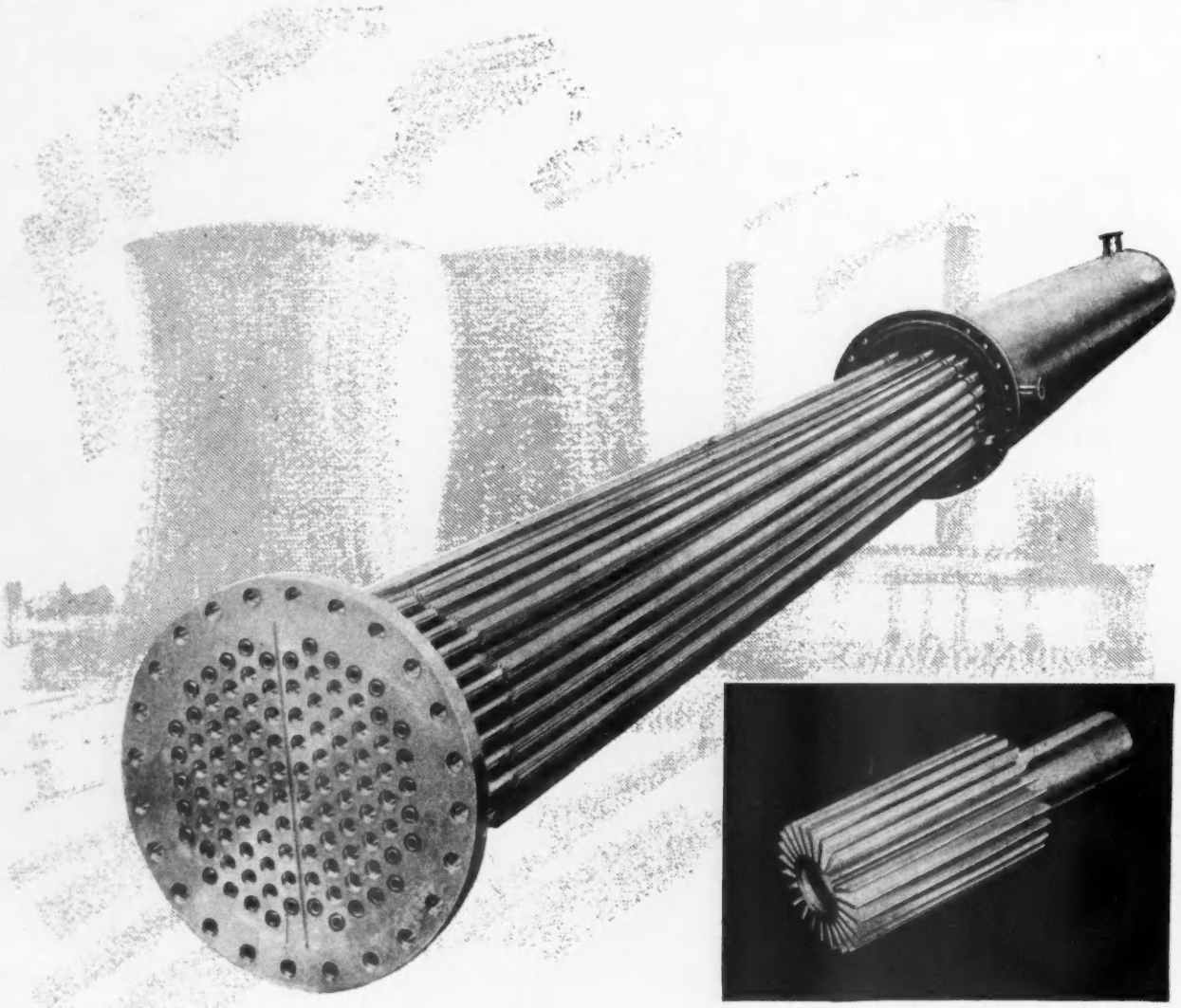

This flash steam heater manufactured by International Combustion Ltd. pre-heats fuel oil at one of the C.E.A. new power stations.
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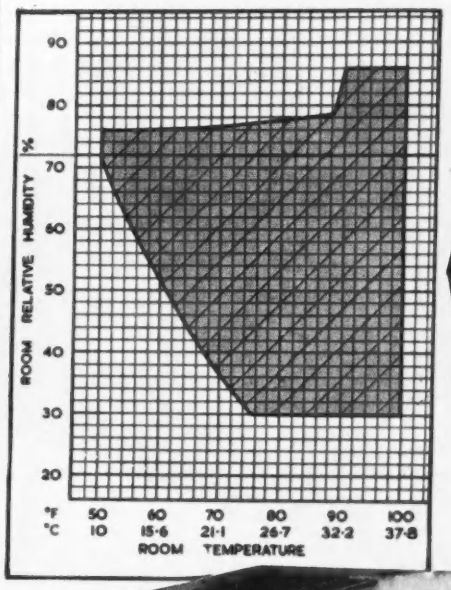
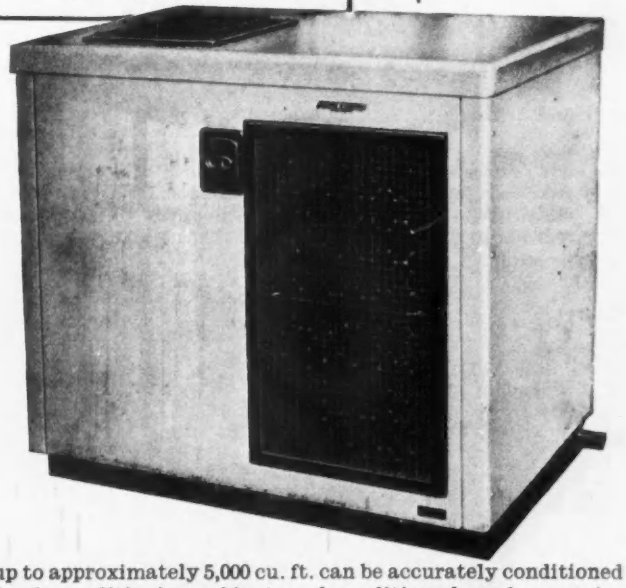


to any conditions within this area



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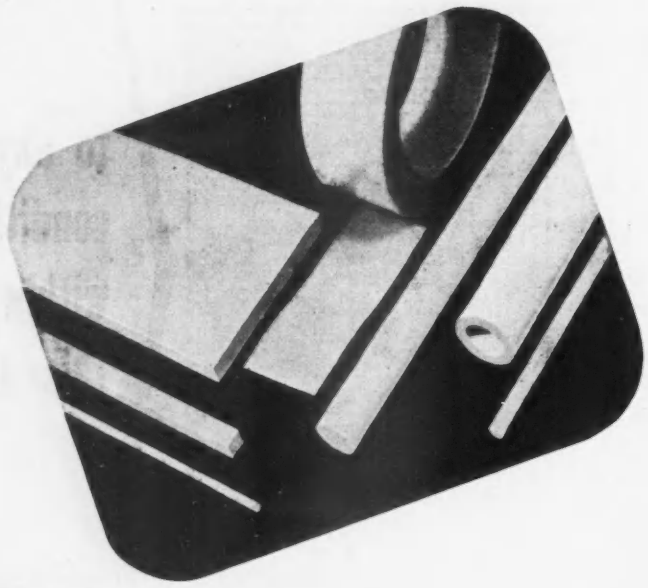

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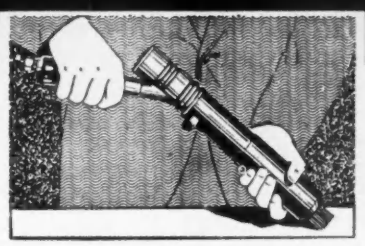

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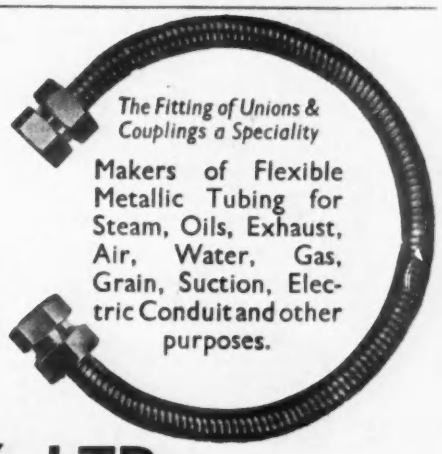
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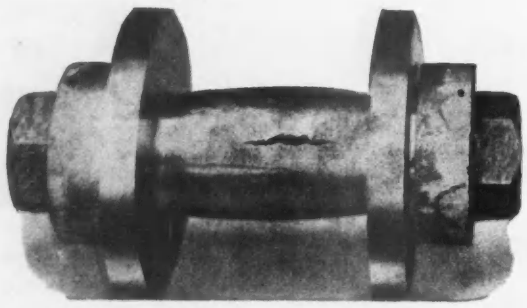
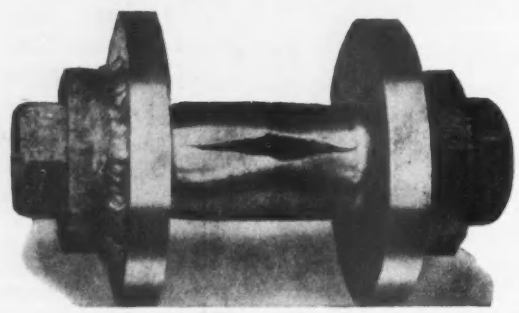


Gun-metal **0·25 in.** *thick—burst at* 4480 *lbs. per sq. in.*



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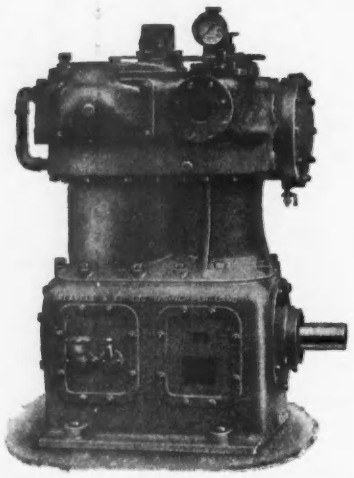

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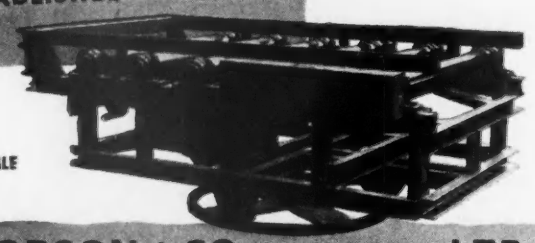

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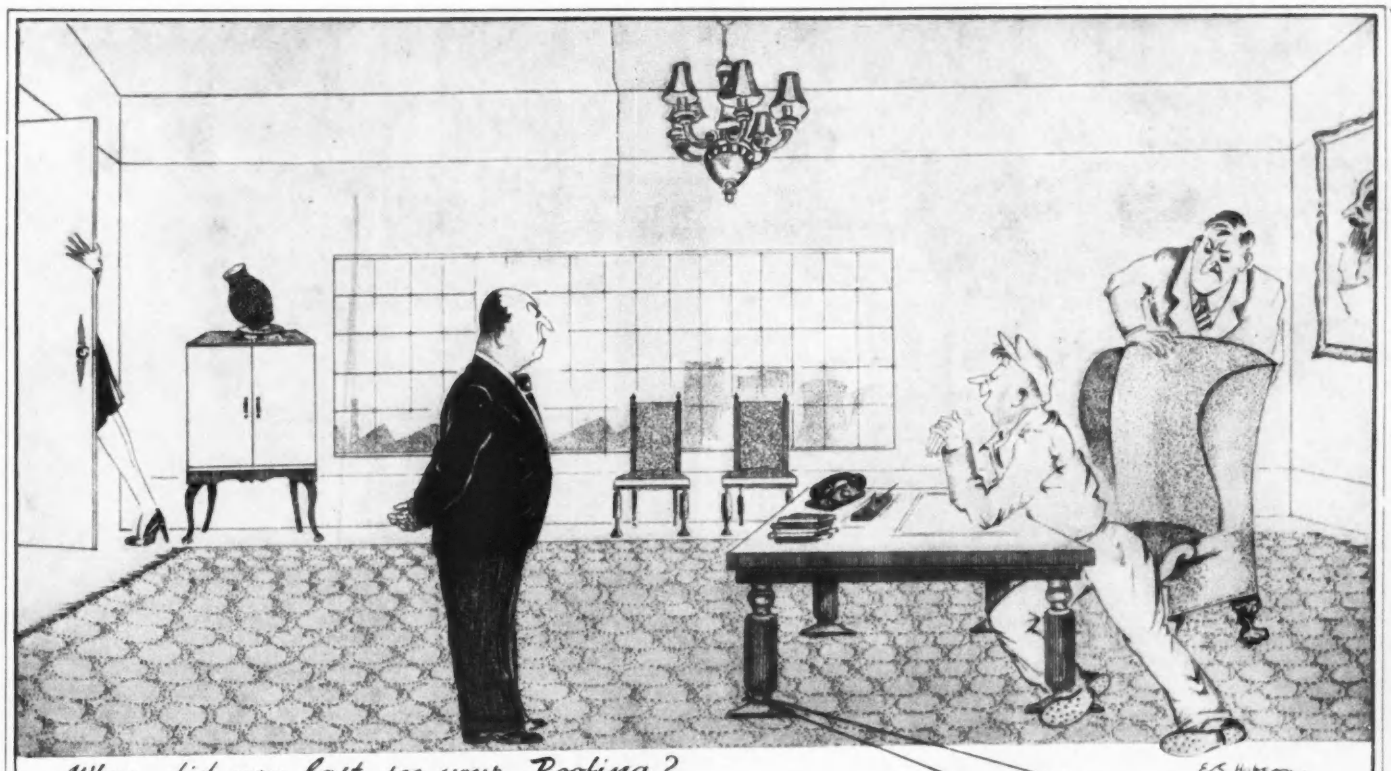

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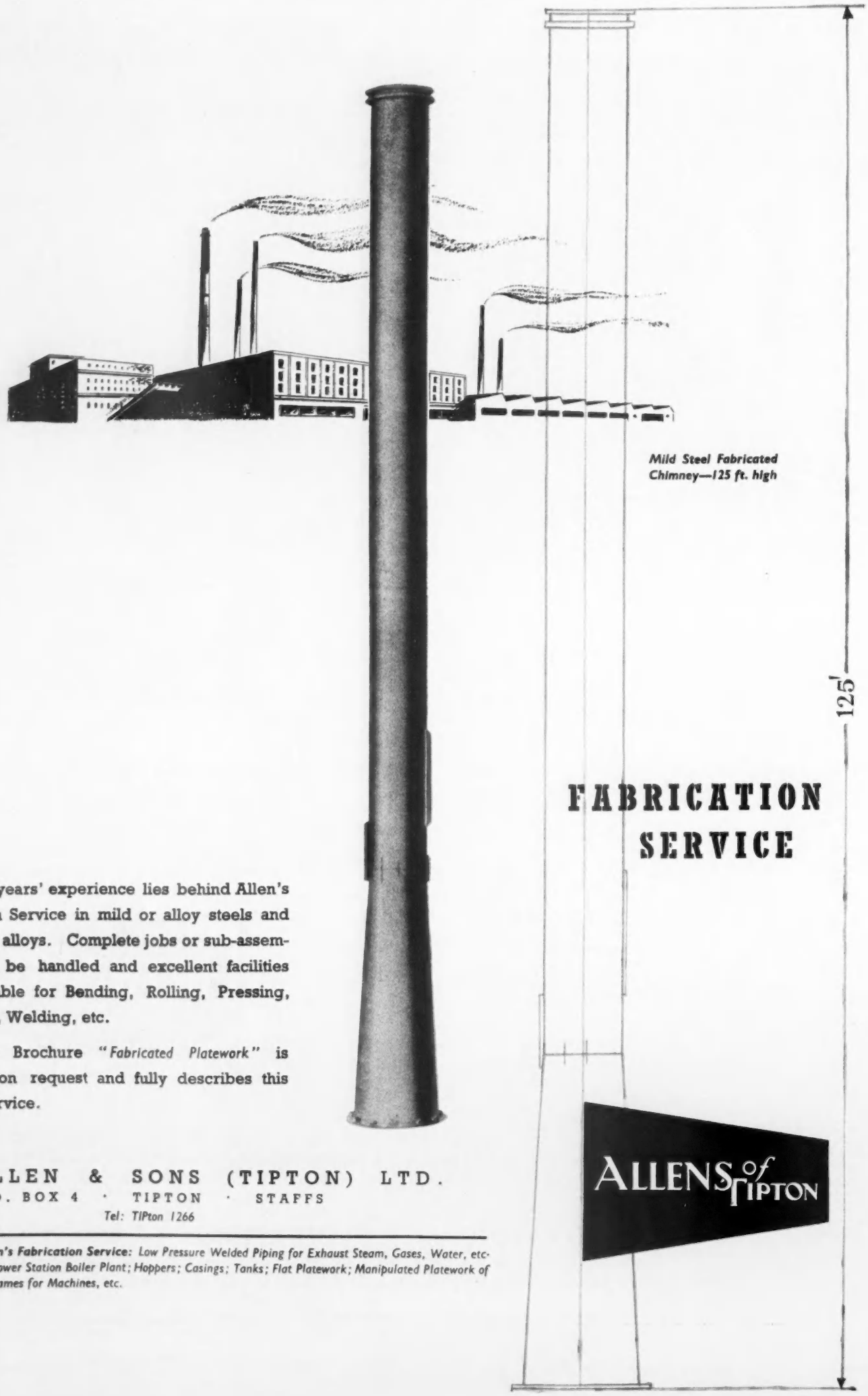

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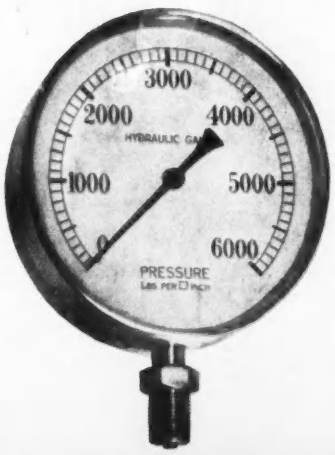

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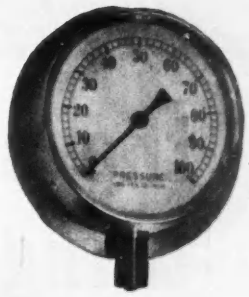

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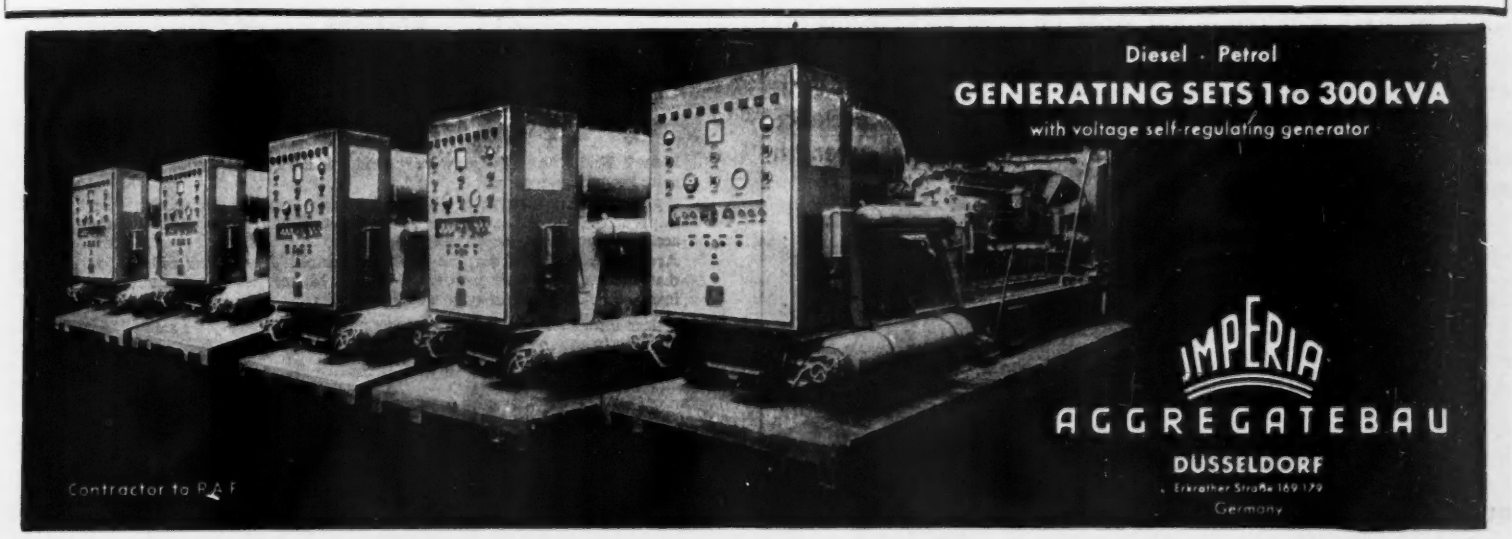

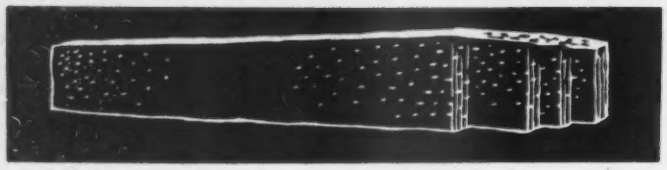

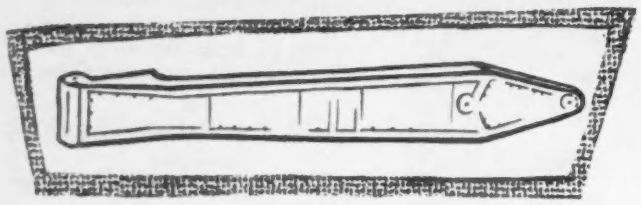

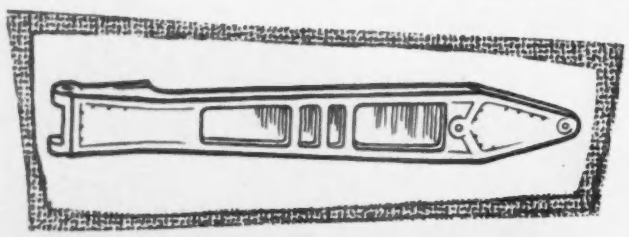

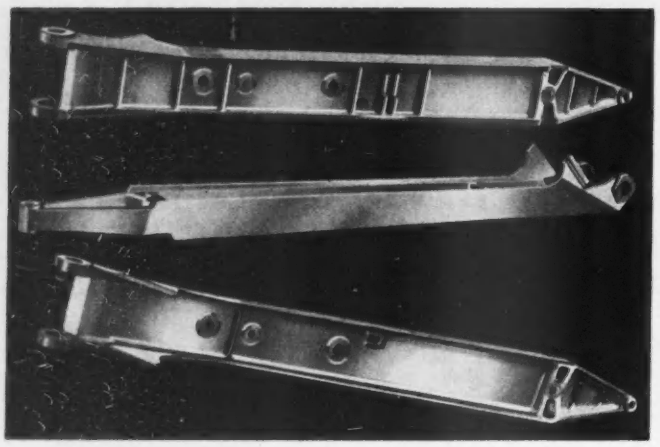

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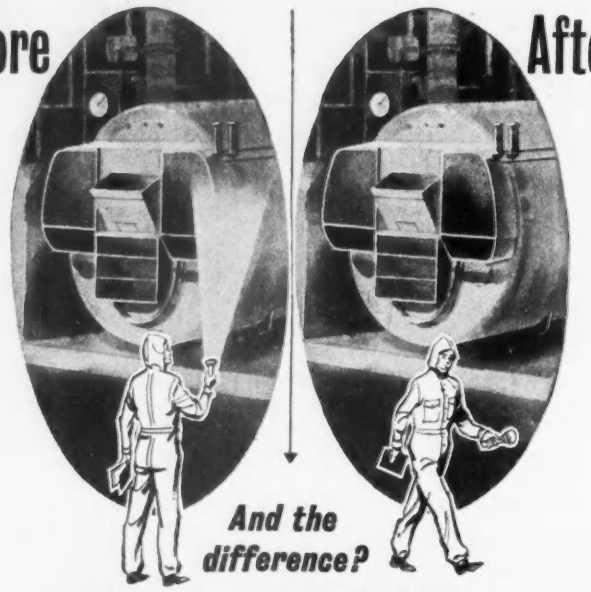
Before After



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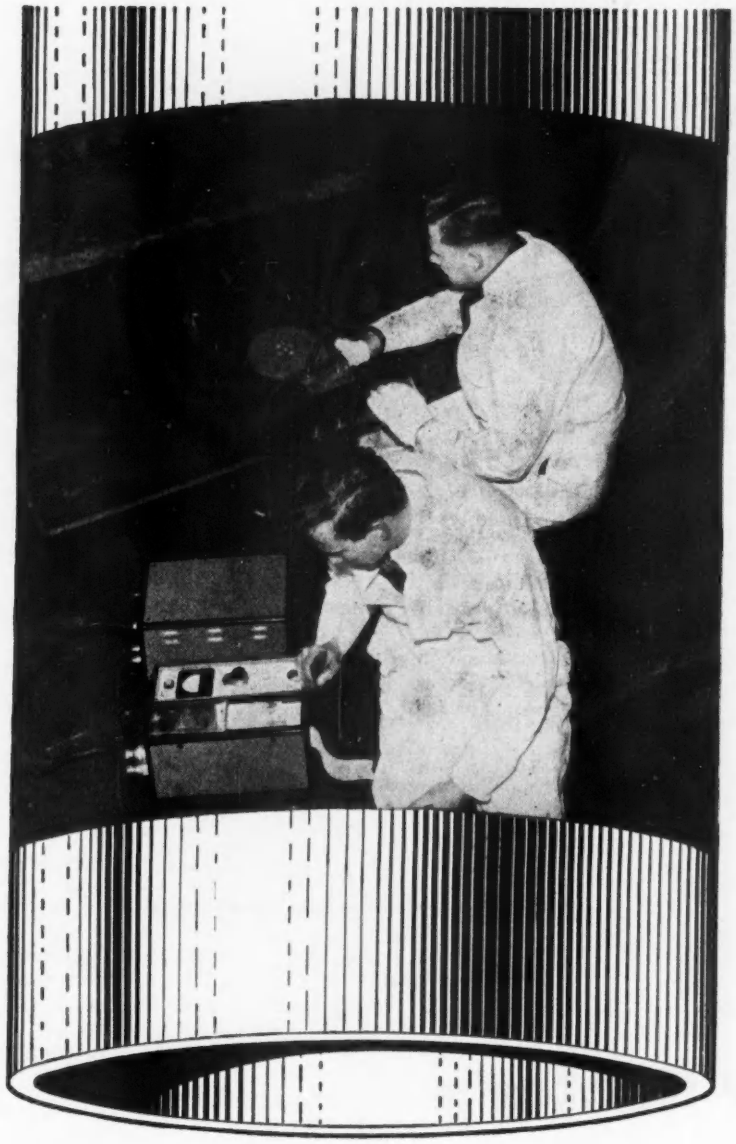

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Introview *

Flaw and corrosion detector for testing non-ferrous metal tubes

* *Manufactured and marketed under licence from Imperial Chemical Industries Ltd.*

The "Introview" flaw and corrosion detector is a new instrument for the non-destructive testing of non-ferrous tubes as used in steam condensers or heat exchangers. The instrument provides a record indicating the extent of corrosion, erosion or thinning of the tube, information which enables impending failure to be diagnosed.

Using the "Introview" equipment, a survey may be made *in situ* and this survey may be on a total or representative percentage basis.

Now this equipment is available, cleaning of condensers can no longer be considered as complete without an "Introview" survey to establish the condition of the tubes. For the shipowner, it provides an important safeguard against unscheduled condenser "shut down" which can lead to high demurrage and similar charges—apart from the direct costs of effecting repairs. For electric power generating authorities, it represents a similar safeguard against the inconvenience of closing down a section of the steam plant through unforeseen condenser tube failure.

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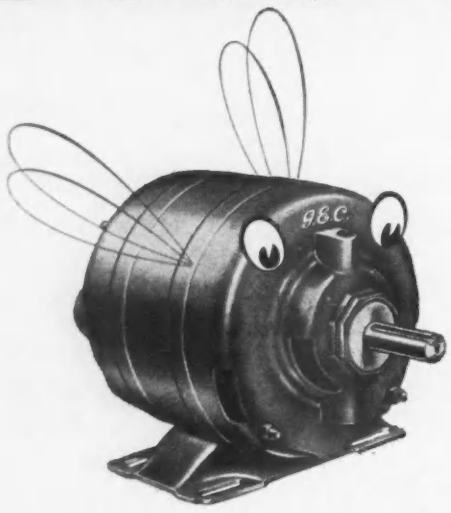

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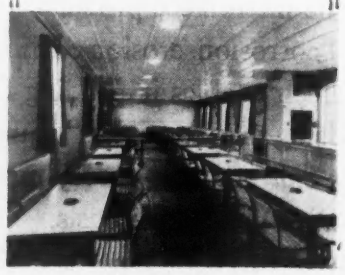

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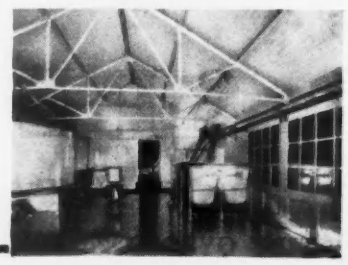

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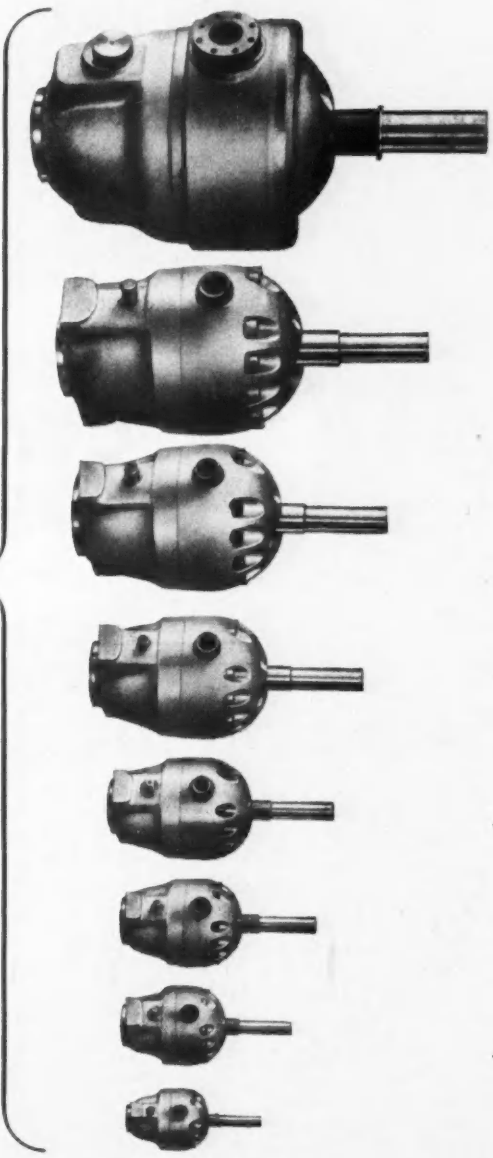

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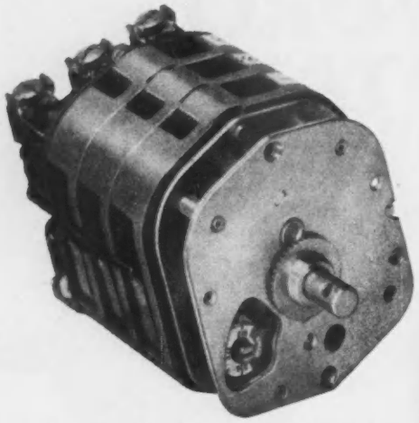

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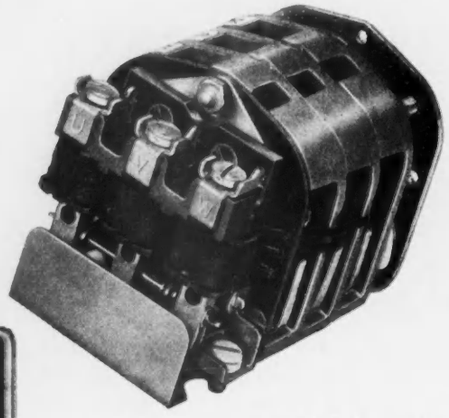

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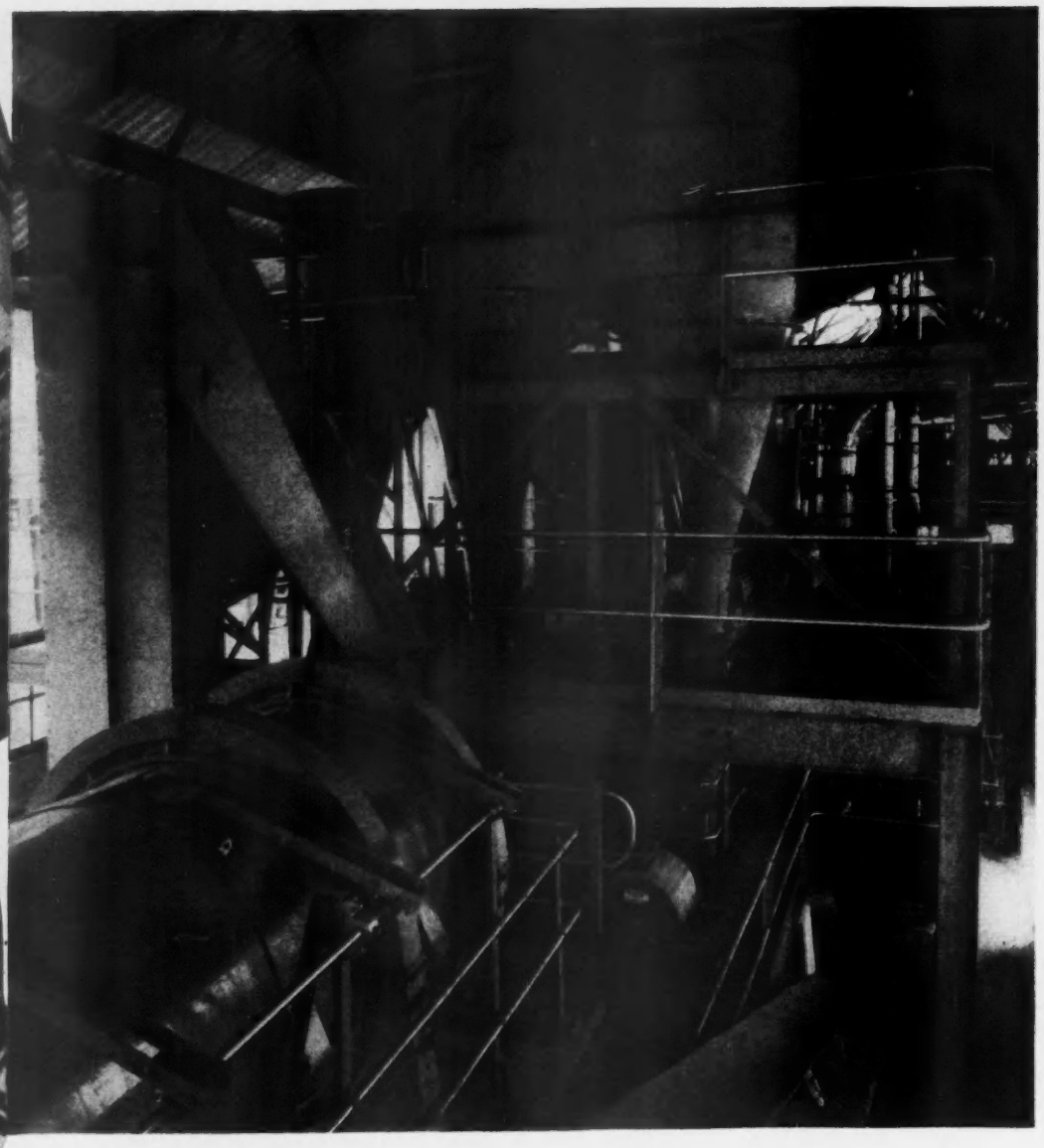

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components of power

The turbine blades are fixed into their positions on the shaft, providing a pattern of complete uniformity. Ultimately, they will drive one of the four large 200 MW turbo generators to be installed in the Richard L. Hearn generating station at Toronto, Canada. Inside the great machine shops at Heaton Works the construction of generators and transformers of all sizes forges ahead to meet the demand for electrical power all over the world.

PARSONS

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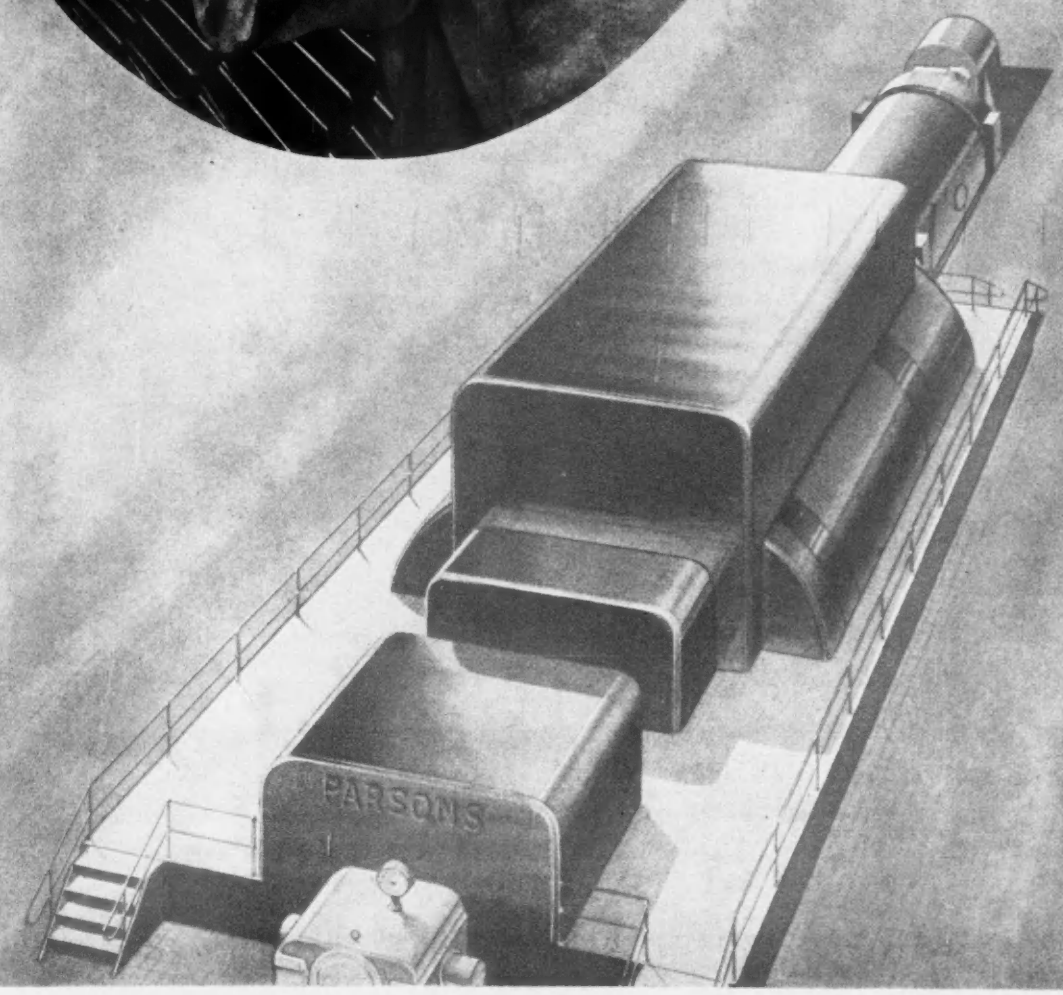
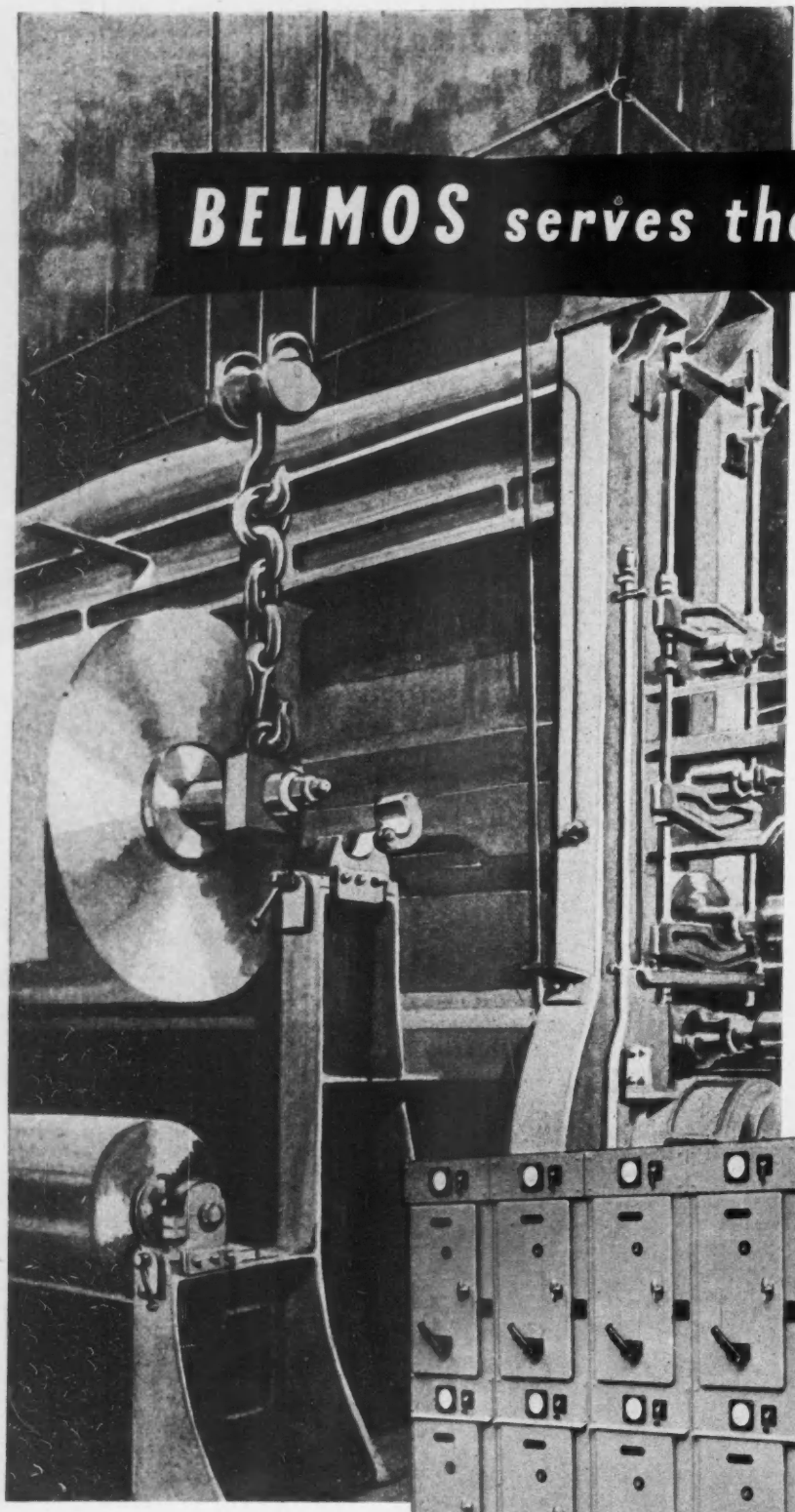


This is the first of two 200 MW turbo generators now under construction for the West Thurrock C.E.G.B. Power Station. The generator will be connected, through a Parsons 210 MVA generator transformer, direct to the 275 kV super grid. Pressure 2350 lb/in². Temperature 1050°F and reheat to 1000°F.

C. A. PARSONS & COMPANY LIMITED · HEATON WORKS · NEWCASTLE UPON TYNE 6



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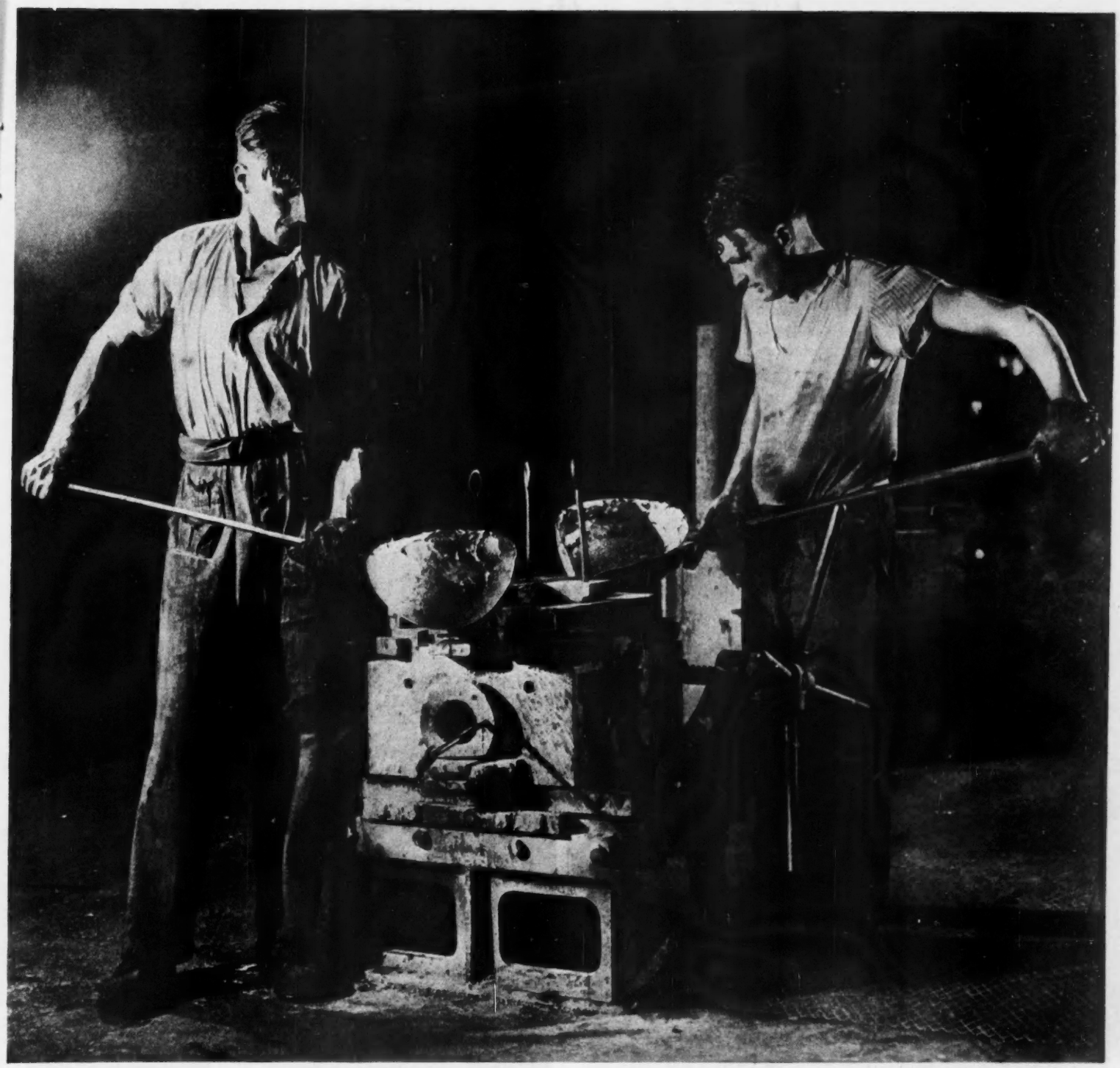

Strictly to Specification

The selection of alloy for a given casting is influenced by design and foundry technique as well as by the physical properties required of the casting in service. Close co-operation between designer and founder is therefore desirable to determine the most suitable alloys and this must be effectively supported by regular checks of incoming materials and foundry melts to ensure conformity to specification.

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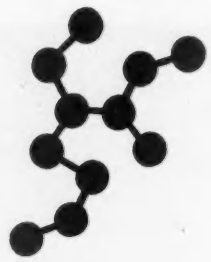

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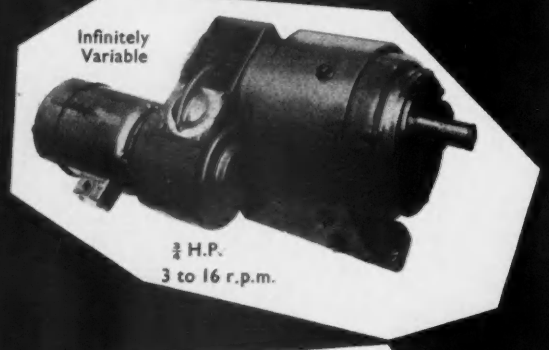

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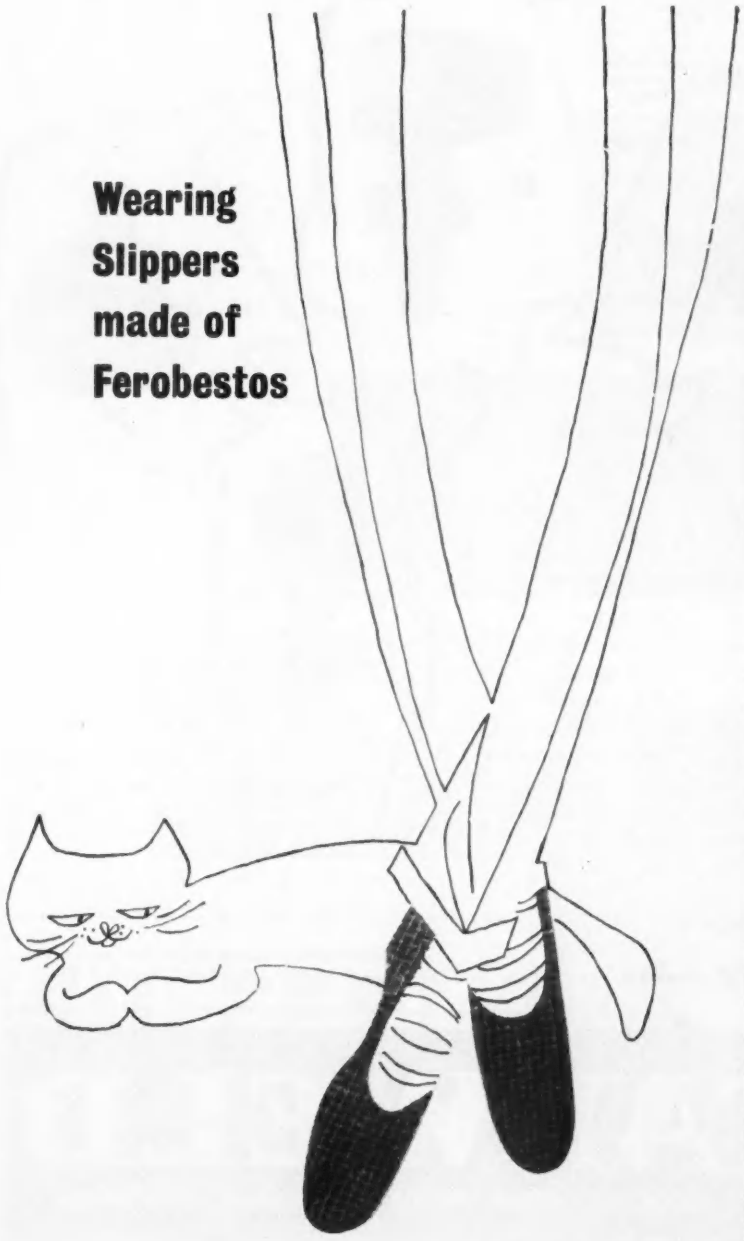

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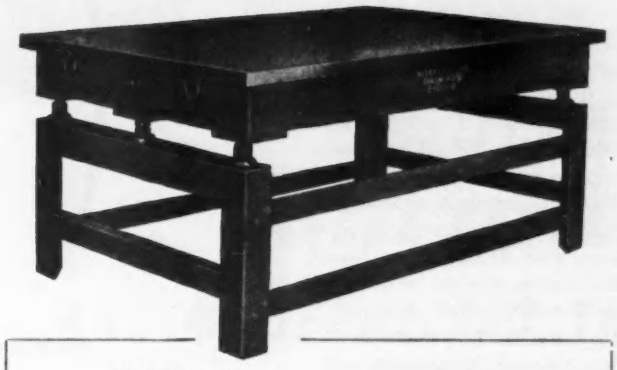

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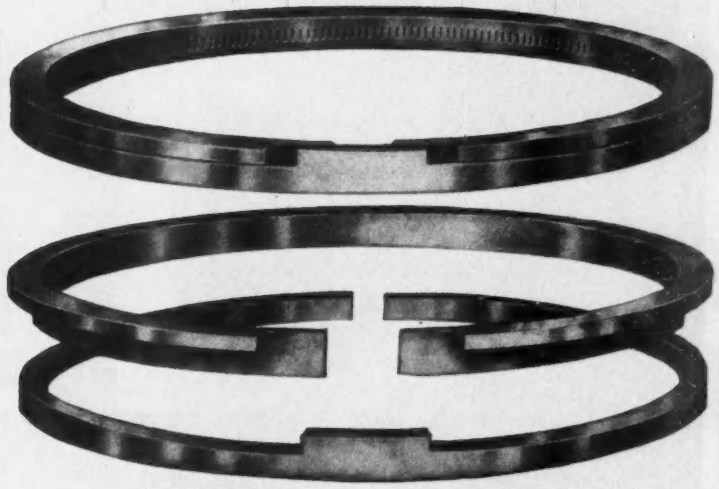

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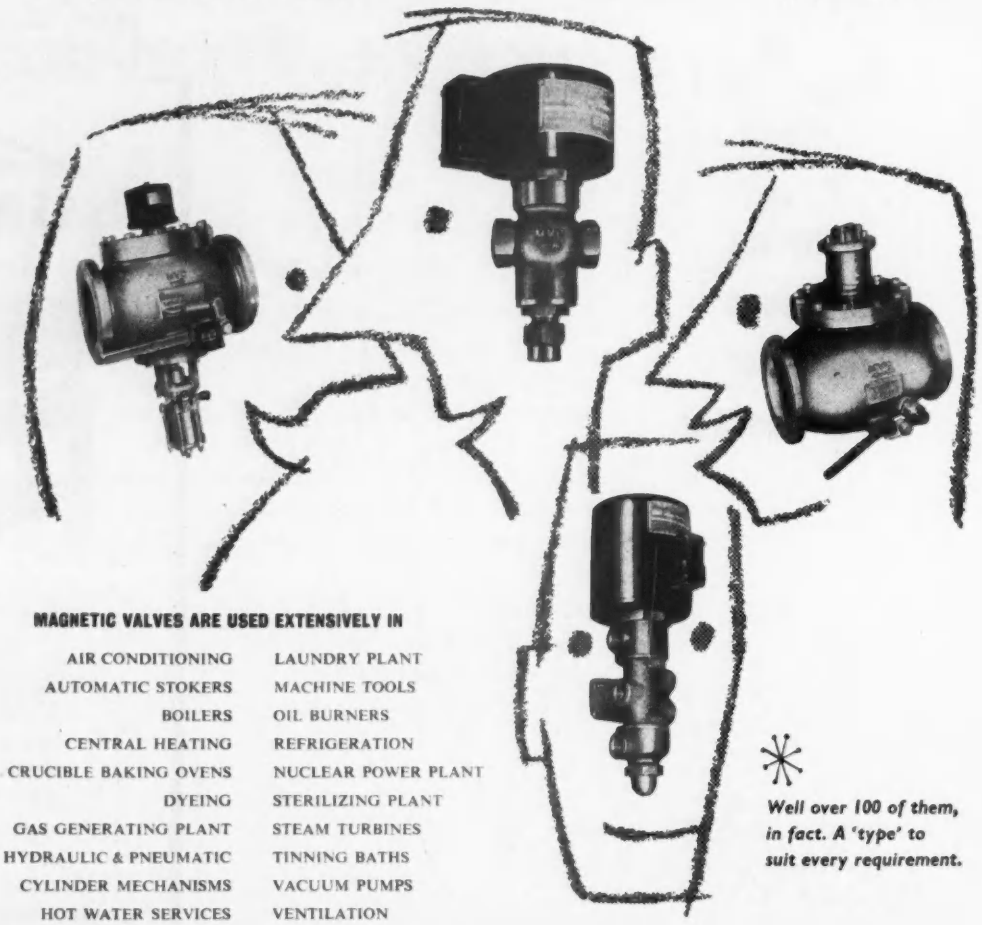

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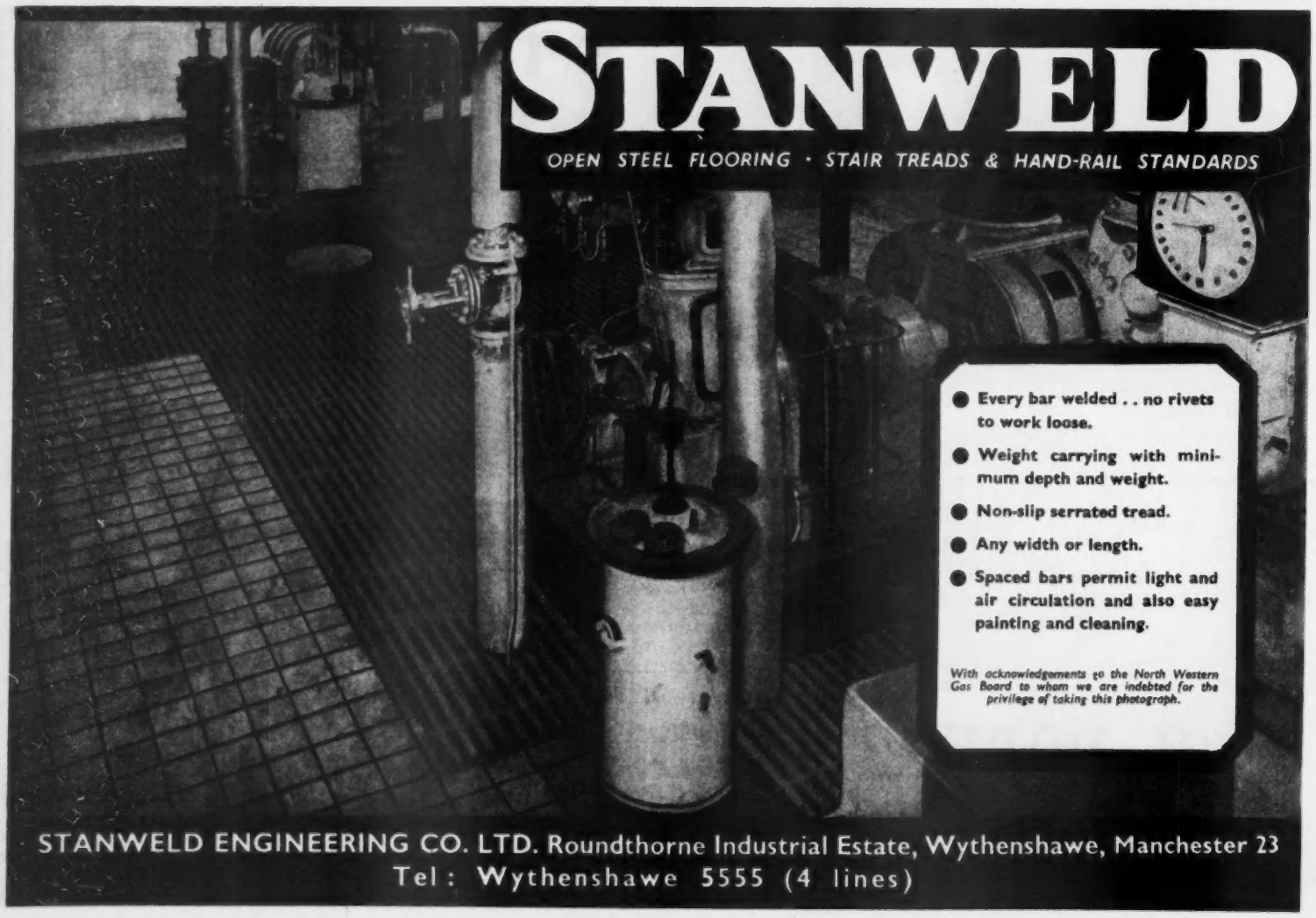
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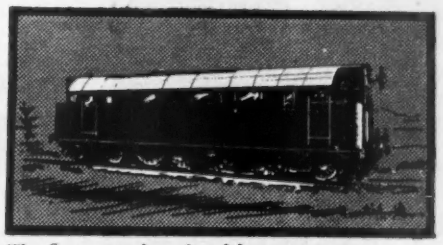
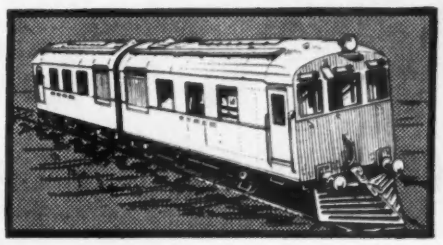
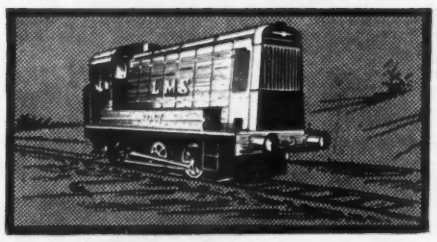


The first main line diesel locomotive in the world. 1000 H.P. Built in 1912.



A 1700 H.P. South American Locomotive with over a million and a half miles service to date.



A 350 H.P. shunter— one of the first in Britain.

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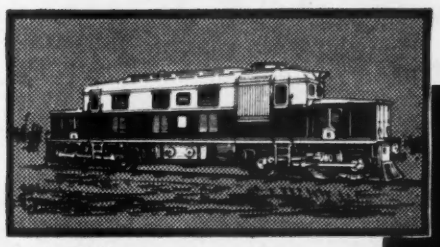
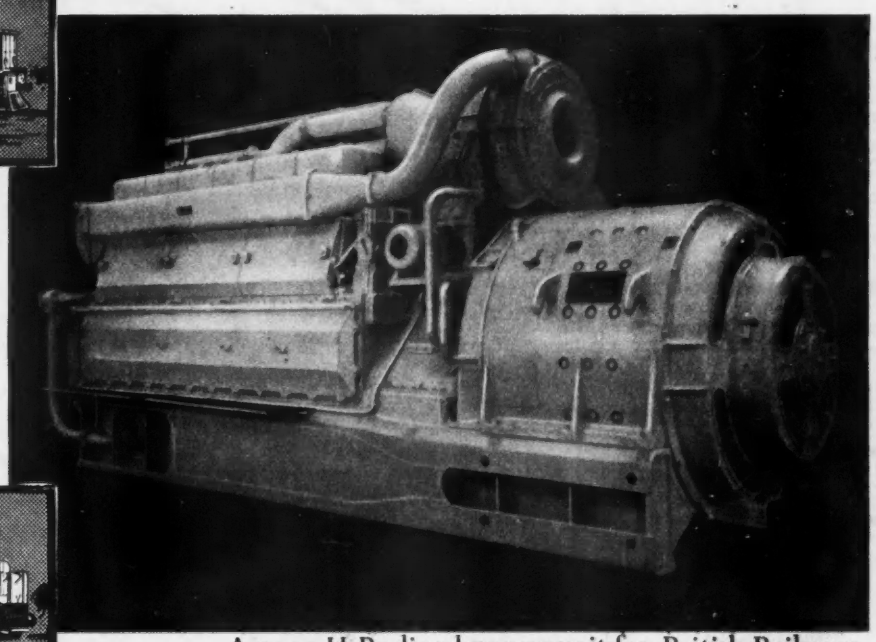


A 735 H.P. unit in operation at 14,000 feet in Bolivia.



A 2300 H.P. diesel power unit for British Railways

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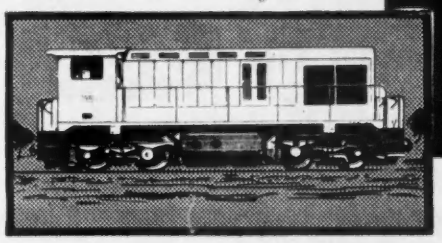
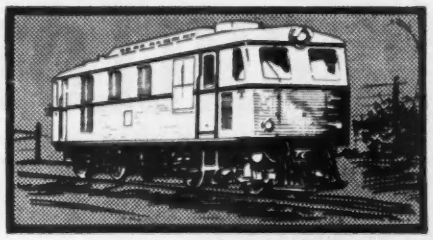
A 850 H.P. diesel-hydraulic Locomotive in French West Africa.





A 735 H.P Locomotive for Thailand.

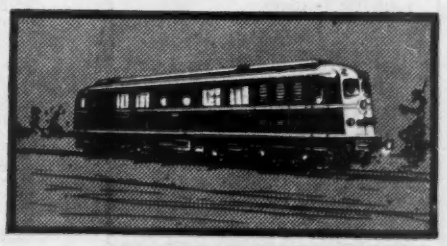
Sulzer Locomotive Engines are built in Great Britain by Vickers Armstrongs (Engineers) Ltd. Barrow-in-Furness.

SULZER BROS. (LONDON) LTD.

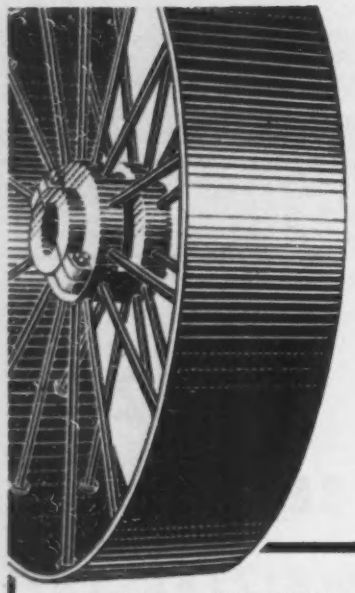
31, BEDFORD SQUARE, LONDON, W.C.1.

Sulzer Brothers Limited have Offices at:—Winterthur—Paris New York—Madrid—Cairo—Rio de Janeiro—Buenos Aires—Kobe—Lisbon Johannesburg—Mexico City. Representatives at:—Brussels Milan—Amsterdam—Copenhagen—Oslo—Stockholm—Helsinki Athens—Istanbul—Algiers—Haifa—Bombay—Karachi—Colombo Singapore—Bangkok—Rangoon—Saigon—Manila—Montreal Bogota—Caracas—Santiago (Chile)—Lima—La Paz Sydney—Melbourne—Wellington—Vienna.

Two 955 H.P. light-weight units in the Australian desert.



A 2000 H.P. heavy freight locomotive for the Great Belt freight line of Paris



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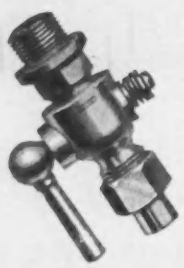

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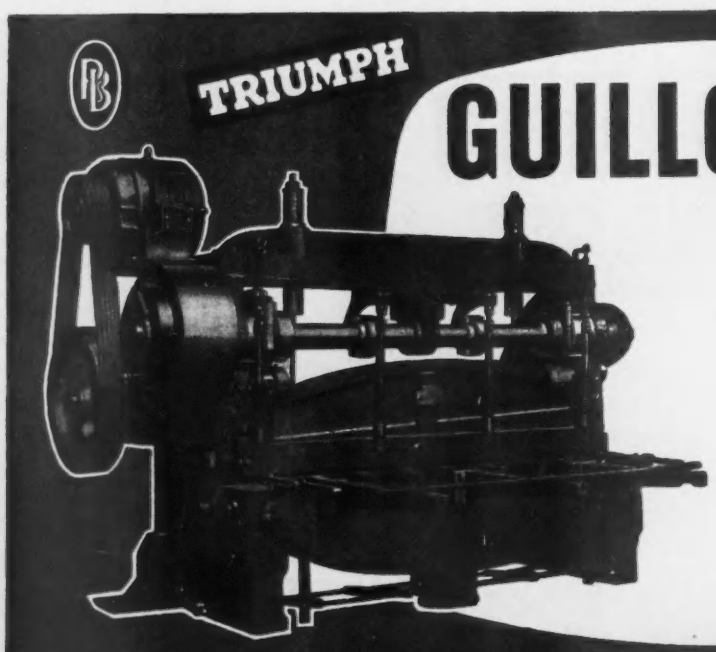

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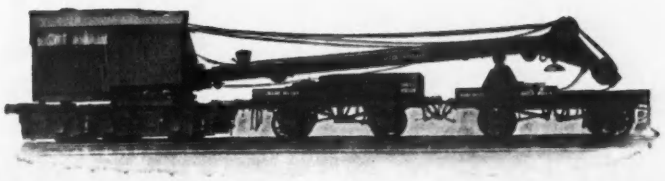

10-ton Diesel Permanent Way Shunting Crane in train formation.

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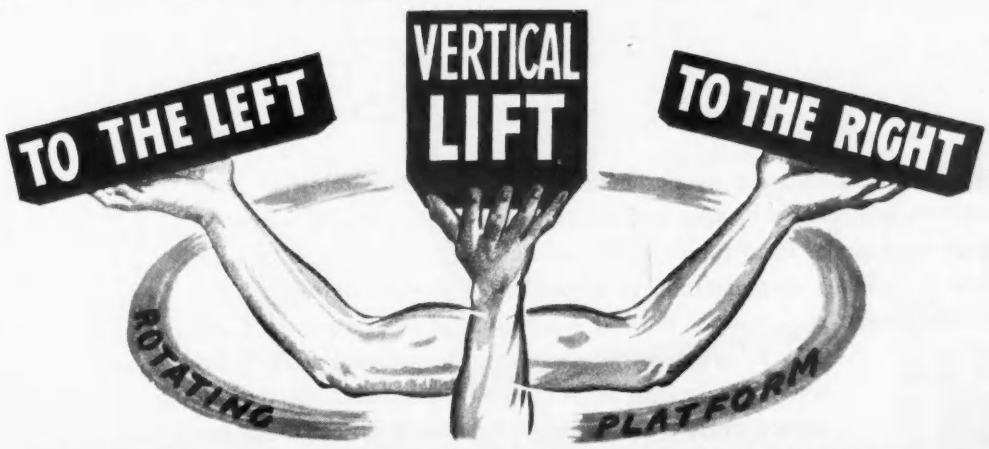
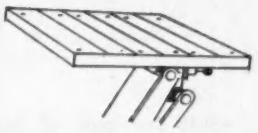
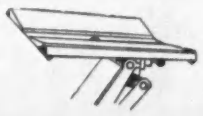


INTERCHANGEABLE PLATFORMS



For other requirements, using the same truck, Flat Platforms or Warp Beam Platforms.



UNIVERSAL HYDRAULIC LIFT TRUCK

with specially designed interchangeable platforms for

• ENGINEERING (Universal Weight Shifting) • PRINTING (Forme Carrying) • TEXTILE INDUSTRIES (Warp Beam Lifting)

A veritable Samson of a Truck with a streamlined figure yet so docile and co-operative. Its special Low Built and narrow chassis, with two fixed wheels and two swivel castors, plus a "pram style" handle makes for easy manipulation in confined spaces.

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★ Capacities ¼ ton, ½ ton, 1 ton. ★ Width 19½". ★ Double-row protected Ball Bearing Wheels. ★ Solid Rubber Tyres. ★ Hydraulic system operated by foot from front or either side. ★ Self Locking Release Valve. ★ Controlled lowering speed. ★ Overload protection valve. ★ Oil reservoir with magnet traps any metal abrasion particles.

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AZOFLEX MODEL 42/63. Combined synchronised printer and developer. Capacity: Cut sheets and rolls up to 42 in. wide. Printing speed: from 6 in. to 15½ ft. per minute. Dimensions: Height 52 in. Width 67½ in. Depth 52 in. with delivery tray extended. Weight: approximately 850 lbs.

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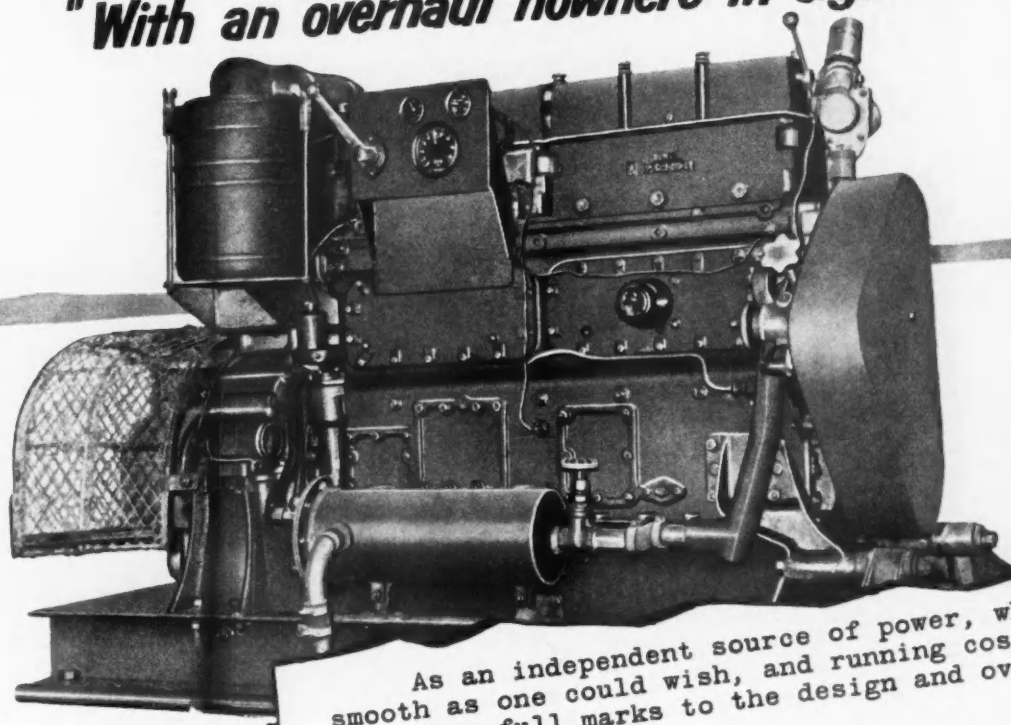

As an independent source of power, where torque is as smooth as one could wish, and running cost at a minimum we must give full marks to the design and overall efficiency of this engine.

The full tale is not yet told. We anticipate to add to this excellent record at some future date.

Please accept our congratulations.

Yours sincerely,
Jordon M. Gwilliam,
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100 hours of continuous trouble-free running, every week for seven years. That's the record of the 6 cylinder 0.600 Leyland industrial engine operated by J. Gwilliam Ltd., at their Coultershaw Mill, Petworth.

Apart from maintenance of injectors and valves . . . oil filters changed regularly and the use of a good lubricant, no other work has been found necessary.

With pistons and cylinder walls in excellent condition, this engine, in the opinion of the operator "is due for many more thousands of hours before a major overhaul will be needed".

Such a testimonial to Leyland efficiency is naturally pleasing—but not surprising. For when you ally 25 years of diesel specialisation to the resources of one of the world's largest organisations in this particular field, plus an after-sales service second to none—then the result must be exceptional. And Leyland engines are certainly all that—and more.

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Sixty times as rigid as sheet metal of the same weight and having all the advantages of a metal surface — stands up to rough usage — hygienic — fire resistant. That's PLYMAX, the metal-faced plywood, made only by Venesta Limited. Light and easy to handle, PLYMAX can be sawn or drilled simply with ordinary tools.

PLYMAX has metal on one or both faces: it is available faced with aluminium or galvanised steel (other metals if required): it is manufactured in 40 standard sizes and in various thicknesses.

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The CROFTSHAW Welding Bench

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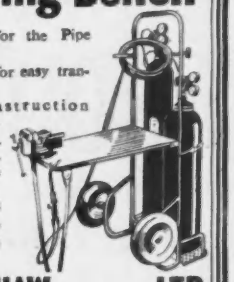
- Folds up for easy transit on site.
- Steel construction throughout.
- Saves erection and installation time by 30%
- PRICE £24
- Trolley without bench etc. £12 10s.



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Site welding and erection specialists—all forms of contract work undertaken.

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(contains colloidal Molybdenum Disulphide and Graphite)

It is used in all cases of assembly — especially of precision machinery, internal combustion engines and electrical apparatus — where careful bedding-down is of importance; also for high temperature lubrication and for machine parts which are difficult to service and dismantle. It will prevent scuffing and corrosion on the treated parts.

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British made by:
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★ *A war surplus* ★
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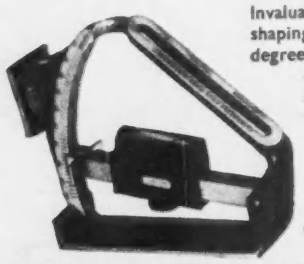

Invaluable for setting angles for milling and shaping and for jigs, etc. Angles from 0 to 90 degrees can be read instantly to an accuracy of one minute of angle. This precision instrument is constructed of brass and weighs 2¼ lbs.

Offered at fraction of cost

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WE WILL GLADLY SUBMIT ON 14 DAYS FREE TRIAL.

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New threads for old..
in damaged components

Hard tough threads in soft materials, used and approved by the Aircraft industry designed for use in soft metal components wood or plastics. Simple to use, remains permanently in place. Full range of standard sizes in B.S.W.: B.S.F.: B.S.P.: B.A., U.N.F.: U.N.C. and Metric thread forms.

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Specialists in JET ENGINE LABYRINTHS, CIRCLIPS, SPRING WASHERS, SPRINGS etc.

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1 Only DUALOK has the patent TWIN Bush for DOUBLE-GRIP. Simple, safe, easy to fit.
2 Only DUALOK is *manufactured* and *guaranteed* without a Keyway.
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2450 c.f.m. BELLISS & MORCOM 2-stage Compressor, 70 lb. air pressure, with direct-coupled 450 h.p. slipring motor, 550 volts, 3-phase, 50 cycles supply, 245 r.p.m., with control gear.

2225 c.f.m. BELLISS & MORCOM 2-stage Air Compressor, 100 lb. air pressure, with direct-coupled 500 h.p. CROMPTON PARKINSON slipring motor, 300 volts, 3-phase, 50 cycles, 223 r.p.m., with control gear.

1550 c.f.m. BELLISS & MORCOM 2-stage Air Compressor, 100 lb. air pressure, with direct-coupled 328 h.p. CROMPTON PARKINSON auto-synchronous motor, 400 volts, 3-phase, 50 cycles, 333 r.p.m., with control gear.

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FOUR 800 c.f.m. INGERSOLL RAND horizontal single-stage Air Compressors, 30 lb. air pressure, each arranged "V" belt drive from 100 h.p. slipring motor, 400 volts, 3-phase, 50 cycles.

NEW 20,000 c.f.m. motor-driven Air Compressor Plant by DANIEL ADAMSON & CO., LTD., incorporating :—

TURBO-COMPRESSOR by ADAMSON/ESCHER WYSS, capacity 20,000 c.f.m., measured at the suction condition of 14·2 p.s.i. absolute, 65° F., discharging against pressure of 100 p.s.i.g., speed 6910 r.p.m. Compressor mounted on baseplate and direct coupled through GEARBOX by DAVID BROWN to :—

Salient pole synchronous MOTOR by METROPOLITAN VICKERS, 4145 h.p. wound for 6600 volts, 3-phase, 50 cycles supply, speed 1,500 r.p.m., with control gear.

May we send you a detailed specification of this equipment ?

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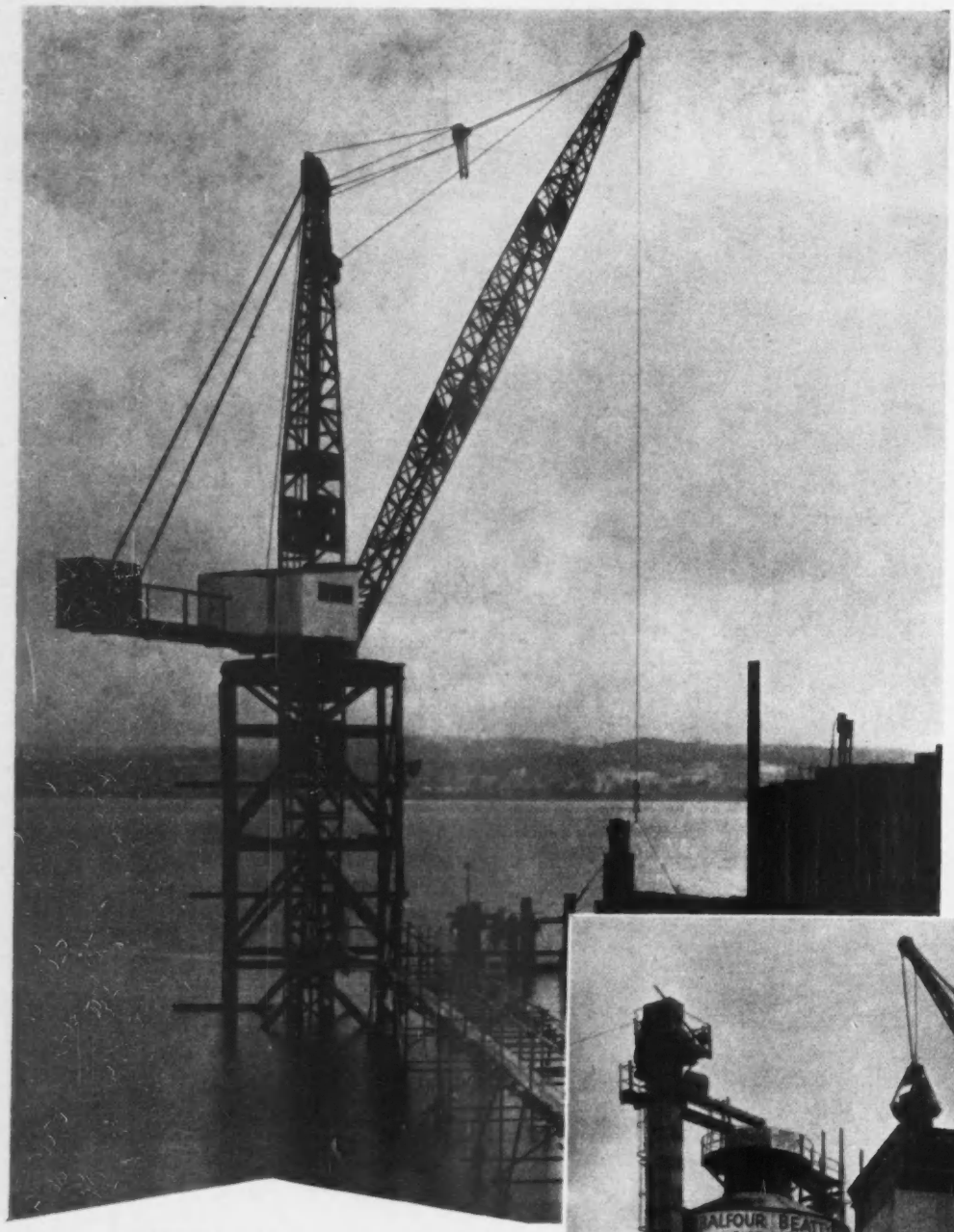


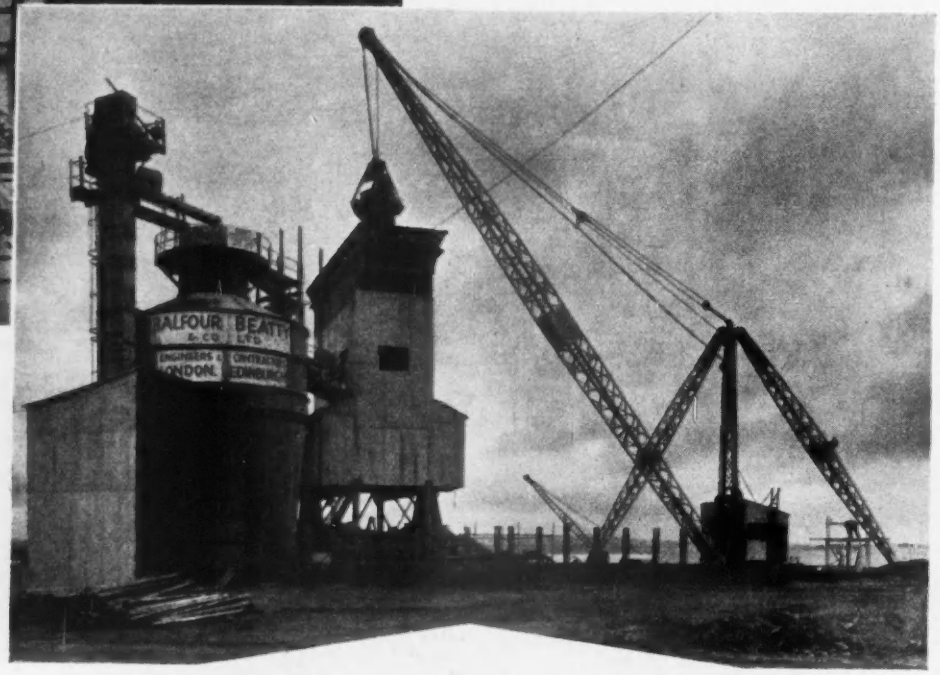
Building AT *Berkeley*

a considerable number of
Butters Cranes
are in use at the new
nuclear power station

Building cofferdams in connection with tunnelling for circulating water intakes . . .

a BUTTERS MONOTOWER CRANE in service

This is a 7 ton model with a 100 ft. jib.
The full load is lifted at 75 ft. radius.



Loading aggregate in weighbatching plant . . .

a BUTTERS DERRICK CRANE in use

An electric two motor grabbing crane

These cranes are owned by Messrs. Balfour Beatty & Co. Ltd.

In addition to these several other Butters Cranes are in use at Berkeley, including four 15 ton Monotower Cranes which are being used in the erection of the reactors.

BUTTERS BROS. & CO. LTD., MACLELLAN STREET, GLASGOW, S.1

London : The Crane Works, Long Lane, Hillingdon, Middlesex.
Birmingham : County Chambers, Corporation Street. Newcastle : 65, Quayside.

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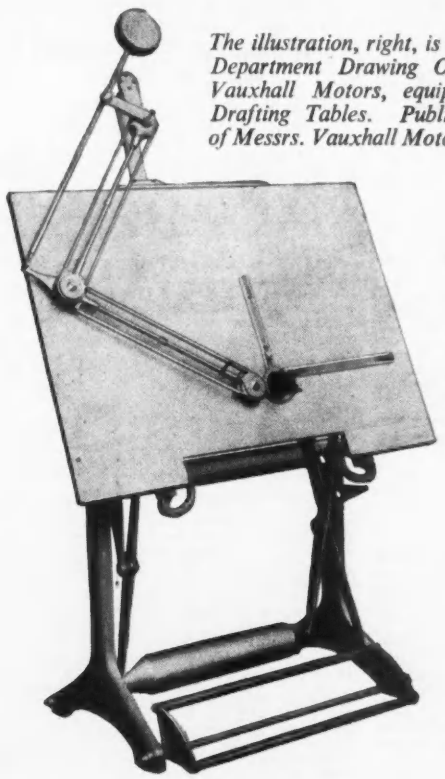
with equipment designed for efficiency

The illustration, right, is of the Engineering Department Drawing Offices at Messrs. Vauxhall Motors, equipped with Mason Drafting Tables. Published by courtesy of Messrs. Vauxhall Motors Limited, Luton.



THE MASON DRAFTING TABLE

No independent type drafting stand is more efficient than this. It will accommodate the largest sizes of drawing board and any type of drafting machine. The strong stand and efficient clamping mechanism ensure absolute rigidity, whilst the drafting cradle—which is pivoted and linkage mounted—has a tremendous range of adjustment. The cradle is finely counter-balanced and finger-light to control. The draughtsman has access to any portion of his board even from a sitting position.

THE ARCLIGHT COMBINED DRAFTING REFERENCE UNIT IN STEEL FITTED WITH THE MASON MINOR DRAFTING TABLE

The " Arclight " steel drafting/reference unit is ideal for use in multi-unit assemblies employing back or side reference facilities. Main features:—top reinforced to support a " Mason Minor " drafting stand assembly; inclined, sliding reference table top; adequate drawer accommodation; top on drafting side overhung to cover a bookshelf and to ensure unimpeded footroom. Finish in hammer grey, stoved enamel. The " Mason Minor " is a fully adjustable drafting stand, which will accommodate Double Elephant or Antiquarian sized drawing boards fitted with parallel movement fittings and straightedge, or the " Simplon " drafting machine.

The units described are among many of those manufactured by Masons that are available for inspection and demonstration on Stand 504, Ground Floor, Grand Hall, I.E.A. Exhibition, Olympia.

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ARCLIGHT WORKS, COLCHESTER Telephone: Colchester 5191-8
291-293 HIGH HOLBORN, LONDON, W.C.1 Tel: CHAncery 6411-4
13-15 ST. VINCENT PLACE, GLASGOW, C.1 Telephone: Central 3775-6
8-10 NEWTON STREET, MANCHESTER, 1 Telephone: Central 9221-2

ALBERT ROAD, STECHFORD, BIRMINGHAM, 33 Tel.: Stechford 3580
51 VICTORIA STREET, SHEFFIELD, 1 Telephone: Sheffield 21776
3 UNITY STREET, BRISTOL, 1 Telephone: Bristol 26996
6 BRITANNIA HOUSE, WELLINGTON ST., LEEDS, 1 Tel: Leeds 23537

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Inch Rate. 48/- per single column inch and *pro rata*. 12 lines to 1 inch. There are reduced rates (*i.e.*, not on a *pro rata* basis) for advertisements of ¼-page (12 column inches) and upwards, e.g., ¼-page £25 10s. ½-page £48. Full page £90.

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Run-On and Semi-Displayed Styles. Both these styles are available for single column width advertisements of any depth up to 12 inches.

Displayed and Illustrated Styles. The minimum size for a Displayed advertisement is 3 inches single column, for an illustrated advertisement it is a ¼-page (12 column inches). Thereafter the sizes for both progress in steps 3 inches deep across 1, 2, 3 or 4 columns.

Use of Box Number. 2/-, which includes forwarding of replies.

Copy Dates. "Run-on" and "Semi-displayed" advertisements by noon Tuesday for publication on Friday same week. "Displayed" and "Illustrated" advertisements by noon Friday for publication on following Friday. All advertisements three days earlier if proofs are required.

Advertisements for publication should be addressed to :— **Classified Advertisement Dept., "The Engineer", 28 Essex Street, Strand, London, W.C.2.**

Urgent advertisements may be telephoned to CENtral 6565.

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HERTFORDSHIRE COUNTY COUNCIL

HATFIELD TECHNICAL COLLEGE

Principal : Dr. W. A. J. CHAPMAN, M.Sc. (Eng.)

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A/M.1. SENIOR LECTURER in AERONAUTICAL ENGINEERING. Applicants must be Graduates qualified to Lecture to Final Degree standard in Mechanics of Flight or Aerodynamics.

A/M.2. SENIOR LECTURER in MECHANICAL ENGINEERING. Applicants must be Graduates in Engineering. Preference will be given to those qualified to Lecture in Theory of Machines and Vibration Analysis to Final Degree standard.

A/M.3. LECTURER in MATHEMATICS. Applicants should be Graduates in Mathematics and will be required to Lecture to Engineering Students on National Certificate, Diploma and Degree Courses. Teaching and some industrial experience is desirable.

DEPARTMENT OF MECHANICAL AND PRODUCTION ENGINEERING

M/P.1. SENIOR LECTURER in MECHANICAL ENGINEERING, to specialise in the Teaching of Theory of Machines and Strength of Materials to Higher National Diploma and Certificate Students.

M/P.2. SENIOR LECTURER in PRODUCTION ENGINEERING to specialise in the teaching of Production Engineering subjects to Higher National Diploma, Certificate and Post-Graduate Students.

These two posts carry administrative responsibilities in the department and staff are encouraged to undertake research. Candidates should possess a Degree and/or good technological qualifications, with sound teaching and industrial experience.

Salaries in accordance with the Burnham Scale for Teachers in Technical Colleges as follows :—

Senior Lecturer : £1350–£1550
Lecturer : £1200–£1350

Assistance is given in obtaining rented housing in the New Town area. Further details and application instructions may be obtained from the Registrar.
E6816

NOTTINGHAM AND DISTRICT TECHNICAL COLLEGE

SHAKESPEARE STREET, NOTTINGHAM

Principal : D. A. R. CLARK, M.Sc.(Tech.), M.I.Mech.E.

RESEARCH ASSOCIATE IN MECHANICAL ENGINEERING

Applications are invited from Engineering Graduates for appointment to the post of RESEARCH ASSOCIATE IN MECHANICAL ENGINEERING. Previous research experience is desirable but not essential. The post offers considerable scope and encouragement will be given to obtain higher qualifications.

Salary : £650 by £50 to £750 per annum.

Further particulars and form of application may be obtained from the Principal, to whom completed forms should be returned not later than 22nd May, 1958.
E6827

CITY AND COUNTY OF BRISTOL EDUCATION COMMITTEE

COLLEGE OF TECHNOLOGY

SENIOR LECTURER

The Governors invite applications for the post of SENIOR LECTURER IN PRODUCTION ENGINEERING in the Department of Mechanical Engineering, with responsibility for Diploma and Certificate Courses in Production Engineering and associated craft courses. The College is being developed to meet the full requirements as a College of Advanced Technology.

Candidates should hold Degree or equivalent and have had teaching and/or industrial and/or research experience. Salary in accordance with the Burnham Technical Report, 1956 : £1350 by £50 to £1550.

Application form, returnable within 2 weeks of appearance of this advertisement, and details from Registrar, College of Technology, Bristol, 7. E6826

PUBLIC APPOINTMENTS

THE UNIVERSITY OF MANCHESTER

RADIO TELESCOPE—DUTY CONTROLLER

A vacancy exists for a post of DUTY CONTROLLER in connection with the 250ft. Steerable Radio Telescope at the Jodrell Bank Experimental Station of the University of Manchester. The commencing salary, which will depend on qualifications and experience, will not exceed £650 per annum, but will be subject to review later.

The radio telescope is driven by remote control and the person appointed will be required to work on a shift basis in the control room of the telescope. Under normal conditions the duties will include the simple following of operating instructions as determined by the research programmes, but quick judgment may be necessary when emergencies arise. The duties include the routine maintenance of the electronic control equipment and instrumentation in the control room. Candidates must be physically fit, with good eyesight, and be capable and willing to work on a shift basis to cover the 24 hours. They must be capable of keeping full, accurate and tidy records relating to the duties entrusted to them. Candidates must hold a Higher National Certificate in Electrical Engineering, or a Senior City and Guilds Certificate in some branch of light current electrical engineering or similar qualifications. Previous experience of the control of plant or apparatus containing both electrical and mechanical parts is desirable.

Applications, giving full details of qualifications and experience, as well as the names and addresses of two referees, should be sent to Professor A. C. B. Lovell, Director, Jodrell Bank Experimental Station, Lower Withington, Macclesfield, Cheshire. E6811

LONDON COUNTY COUNCIL

POPLAR TECHNICAL COLLEGE
POPLAR HIGH STREET, E.14

MECHANICAL ENGINEERING DEPARTMENT

ASSISTANTS

Two Grade B ASSISTANTS for National Certificate and/or National Diploma and/or City and Guilds classes. Salary : £650 by £25 to £1025, plus L.A. additions for training, increments within scale for experience.

Forms from Secretary, to be returned by 30th April, 1958. (626) E6851

THE UNIVERSITY OF MANCHESTER

JODRELL BANK EXPERIMENTAL STATION

SENIOR ENGINEER

There is a vacancy for a SENIOR ENGINEER in connection with the 250ft. Steerable Radio Telescope at the Jodrell Bank Experimental Station of the University of Manchester. The successful candidate will be responsible for the safety of personnel and the maintenance of the telescope, including the electrical and mechanical parts and the electronic instrumentation associated with the drive and computing systems. In addition, he will be required to organise the duties and routine of the controllers ; to act, when required, as controller to ensure 24-hour continuity of the research programmes ; and to undertake such other duties as may be assigned to him.

Applications are invited from persons with experience in the supervision and maintenance of heavy engineering and electrical equipment. Some general acquaintance with electronics is desirable. Membership of the Institution of Mechanical and/or Electrical Engineers or a First Class Board of Trade Certificate in Marine Engineering, Membership of the Institute of Marine Engineers ; or some other equivalent qualification, is essential.

The commencing salary will depend on qualifications and experience, up to a maximum of £1250 per annum, with membership of the F.S.S.U. and children's allowance.

Applications, giving the names and addresses of two referees, should be addressed to The Bursar, University of Manchester, Oxford Road, Manchester, 13. E6836

PUBLIC APPOINTMENTS

CITY OF LEICESTER

EDUCATION COMMITTEE

COLLEGE OF TECHNOLOGY AND COMMERCE

ASSISTANT LECTURER

ASSISTANT LECTURER (Grade B) required in the School of Engineering, from September, 1958, to teach largely Applied Mechanics, Thermodynamics and Engineering Drawing in Ordinary National Certificate Courses. Some City and Guilds of London Institute and Higher National work may also be required.

Salary : Burnham Technical Scale, £650 by £25 to £1025 per annum, with Degree and training allowances and increments for approved teaching and/or industrial experience and War Service.

Forms of application and further particulars can be obtained from the Registrar, College of Technology and Commerce, Leicester, to whom the completed forms should be returned as soon as possible. E6874

ESSEX EDUCATION COMMITTEE

THURROCK TECHNICAL COLLEGE, GRAYS

ASSISTANT LECTURER

Required from 1st September, 1958, an ASSISTANT LECTURER, Grade B, to teach General Engineering subjects to Ordinary National Certificate level (and possibly to Higher National Certificate level) in Metallurgy and Machine Tools and Processes.

Candidates should hold the appropriate Professional qualifications and have had adequate industrial experience in direct association with Production Engineering. Teaching experience desirable.

Salary : £650 by £25 to £1025, with additions for Degree or equivalent and approved training. Increments within scale for previous teaching service, approved industrial experience and war/national service.

Details and application forms (stamped, addressed foolscap envelope) from the Clerk to the Governors, Divisional Education Office, Upminster Court, Hall Lane, Upminster, Essex. Closing date 30th April. E6875

EAST HAM COUNTY BOROUGH

GRAMMAR SCHOOL FOR BOYS

HEAD OF DEPARTMENT

A new Department of Engineering will be established next September in this large Grammar School of 900 boys, and a fully equipped workshop is in course of construction.

Applications are invited for the post of HEAD OF THIS DEPARTMENT (Grade "B," allowance £200) from well-qualified candidates, preferably with industrial experience.

The successful candidate will be expected to develop the Course to an advanced level and to teach Engineering Metalwork and Workshop Practice to Grammar School pupils and to pupils, aged 14–16 years, from two neighbouring Secondary Schools with Engineering Courses.

Burnham Scale (London Area).

Application forms (returnable as soon as possible) and further particulars, from Chief Education Officer, Town Hall Annexe, Barking Road, London, E.6. E6870

BEDFORDSHIRE EDUCATION COMMITTEE

THE MANDER COLLEGE

BEDFORD

LECTURER

Applications are invited for appointment as LECTURER IN MECHANICAL ENGINEERING as from 1st September, 1958. Candidates should be Graduates with industrial experience, qualified to teach Applied Thermodynamics and Fluid Mechanics to H.N.C. standard.

Salary scale : £1200 by £30 to £1350. Increments may be added, up to the maximum, for approved industrial experience.

Forms of application and further particulars obtainable from the College Principal.

T. S. LUCKING,
Director of Education.
E6787

PUBLIC APPOINTMENTS

ROYAL CORPS OF NAVAL CONSTRUCTORS

SCHOOLS ENTRY

A COMPETITION FOR ENTRY INTO THE ROYAL CORPS OF NAVAL CONSTRUCTORS will be held in July, 1958.

Accepted candidates will be established as Probationers in the R.C.N.C. and will undergo a 2-year course of training at the R.N. Engineering College, Manadon, and in H.M. Dockyard, Devonport, followed by a 3-year course at the R.N. College, Greenwich.

Candidates must be aged between 18 years and 19 years 6 months, inclusive, on 1st September, 1958.

Candidates with the General Certificate of Education will be required to have passed at Advanced Level in at least Pure Mathematics, Applied Mathematics and Physics, and to produce evidence of general education at Ordinary level.

Candidates with the Scottish Leaving Certificate will be required to have higher grade passes in Physics and Mathematics and at least lower grade passes in English and a language other than English and two other subjects (preferably mathematical).

Candidates from schools in Northern Ireland will be required to produce a certificate from the Ministry of Education in Northern Ireland, showing a comparable standard to that above.

The work of the R.C.N.C. covers all aspects of design construction and repair of H.M. Ships. Members undertake to serve wherever required at Admiralty Headquarters and outports in the United Kingdom, and at Royal Dockyards at Home and Abroad. The Head of the R.C.N.C. is the Principal Technical Adviser to the Board of Admiralty.

The starting pay of a Probationer at age 18 will be £535. A deduction of £75 is made when living in at the R.N. Engineering College, Manadon, or at the R.N. College, Greenwich. The successful Probationer can expect appointment as Assistant Constructor at age 23 or 24, with a starting salary in London of not less than £905 and £935, respectively Promotion to Constructor normally takes place at about age 30, with a salary which may be expected to be not less than £1435, rising in nine years to not less than £2050. Promotion to higher ranks is by selection.

Full particulars may be obtained from the Secretary of the Admiralty, C.E. Branch II, Empire Hotel, Bath, to whom final application must be submitted by 16th June, 1958. E6608

LONDON COUNTY COUNCIL

DAY COLLEGES

APPOINTMENTS

Day Colleges (with Evening Departments). Applications invited for following posts, for work with full and part-time day release and evening students. Work is mainly to G.C.E. (O. level) and First Year O.N.C. Burnham F.E. salary scales.

Grade B ASSISTANT, £650 by £25 to £1025 (man) ; £620 to £1025 (woman).

Grade A ASSISTANT, £475 by £25 to £900 (man) ; £455 14s. to £900 (woman).

Plus £36 or £48 London Allowance, additions for qualifications and training ; increments within scale for experience. Forms from Principals at Colleges, to be returned by 2nd May, 1958.

BRIXTON DAY COLLEGE, Brixton Hill, S.W.2.—Grade A ASSISTANTS (I), Elementary Science for Technical Course students.

HAMMERSMITH DAY COLLEGE, Brook Green, W.6.—Grade B ASSISTANT for Science throughout College. Grade A ASSISTANT for Science, mainly with Non-Examination classes.

KINGSWAY DAY COLLEGE, Keeley Street, W.C.2.—Grade B ASSISTANT (plus £100 allowance) as Senior Science Teacher. Should offer at least two of Biology, Chemistry, Physics, Engineering Science and Mathematics.

NORTH LONDON DAY COLLEGE, at Working Men's College, Crowndale Road, N.W.1.—Grade A ASSISTANT for Mathematics and Physics.

WOOLWICH DAY COLLEGE, Vicarage Road, S.E.18.—Required, owing to expansion of work : (I) Grade B ASSISTANT (plus £100 allowance) for Mathematics and Science throughout College. Should be Graduate or hold H.N.C. in Electrical Engineering ; (II) Grade B ASSISTANT for Engineering Drawing and Workshop Practice ; (III) Grade A ASSISTANT for Science and Mathematics. (707). E6884

PUBLIC APPOINTMENTS

COUNTY BOROUGH OF DARLINGTON

COLLEGE OF FURTHER EDUCATION

Principal :
C. E. BEYNON, B.Sc., F.R.I.C., A.Inst.P.

APPOINTMENTS

Required, in September :
DEPARTMENT OF ENGINEERING

LECTURER IN APPLIED MECHANICS AND MATHEMATICS to H.N.D. and H.N.C. Final levels.

ASSISTANT (Grade A) IN MACHINE SHOP ENGINEERING and/or SHEET METAL WORK.

Salaries (basic) as follows :—Lecturer, £1200 by £30 to £1350 ; Assistant (Grade A), £475 by £25 to £900. Possible additions for industrial/professional and teaching experience and training.

Further particulars and application forms (to be completed and returned not later than May 5th) may be obtained from the Education Office, North Lodge, Darlington.

D. PETER,
Chief Education Officer.
E6858

STAFFORDSHIRE POTTERIES WATER BOARD

APPOINTMENT OF ASSISTANT IN DISTRIBUTION DEPARTMENT

Applications are invited for the position of ASSISTANT IN DISTRIBUTION DEPARTMENT, Grade A.P.T. II (£725 to £845 per annum).

Applicants should be neat and expeditious draughtsmen with surveying experience, and have had experience in a Water Undertaking on distribution work.

The Board will provide housing accommodation if required, and reasonable removal expenses will be allowed by the Board.

The appointment is subject to the provisions of the National Scheme of Conditions of Service ; to the provisions of the Local Government Superannuation Acts ; to termination by one month's notice on either side, and to the successful candidate passing a medical examination.

Applications, stating age, full details of training, qualifications, present and previous appointments, details of experience, together with copies of two recent testimonials, or the names of two persons to whom reference can be made, should be forwarded to the undersigned not later than 5th May, 1958.

C. V. BROWN, M.I.C.E., M.I.Mech.E., M.I.W.E.,
Engineer and Manager and Clerk.
Albion Street,
Hanley,
Stoke-on-Trent. E6821

SHEFFIELD REGIONAL HOSPITAL BOARD

ENGINEERING ASSISTANT

Applications for the post of ENGINEERING ASSISTANT, Grade II, are invited from men who have had extensive practical experience in the installation of heating and ventilating systems and who are desirous of making a career in the design and installation of such systems in hospitals. Applicants should either hold or be studying for the Ordinary National Certificate in Mechanical Engineering, or hold other appropriate technical qualifications.

Commencing salary between £525–£590, according to age and experience, rising by annual increments to £730.

Applications, stating age and experience, should be sent to the Secretary to the Board, Fulwood House, Old Fulwood Road, Sheffield, 10, not later than 28th April, 1958. E6844

LONDON TRANSPORT

DEVELOPMENT SECTION, CHISWICK

TECHNICAL ASSISTANTS

London Transport require TECHNICAL ASSISTANTS, Development Section, Chiswick, to assist in investigation into service operation of road vehicle chassis in relation to mechanical and/or electrical design and development. Suitable apprenticeship, Higher National Certificate or equivalent required. Commencing salary up to £655 per annum, according to age and experience, additional payments for certain recognised qualifications. Medical examination ; free travel.

Applications within 7 days, to Staff and Welfare Officer (F/EV 682), London Transport, 55, Broadway, S.W.1. E6850

NORTH WESTERN GAS BOARD

DRAWING OFFICE—BOARD HEADQUARTERS

SECTION LEADER

Applications are invited for the pensionable appointment of SECTION LEADER in the Drawing Office of the Technical and Planning Division of the Board at Bradford Road, Manchester, 10.

Applicants must have had a wide experience in the design and detailing of :—

(a) Structural Steelwork.
(b) Reinforced and Prestressed Concrete Structures, Foundations, &c.

The salary offered for this appointment is in Grade A.P.T. 10 (£860/£960 p.a.), with placing on the grade according to qualifications and experience.

Applications, including the names of two referees, should reach the Secretary, N.W.G.B., Bridgewater House, 60, Whitworth Street, Manchester, 1, within 7 days. E6817

PUBLIC APPOINTMENTS

AGRICULTURAL DEPARTMENT

SIERRA LEONE

AGRICULTURAL ENGINEER

Responsibility for maintenance and overhaul of the Department's motor vehicles and agricultural machinery and equipment and advising on suitable types of mechanical equipment.

Appointment is on contract for 18–24 months in the salary range £1470 to £2145 per annum gross, with a gratuity of £37 10s. for each three months' satisfactory service. An allowance of £75 per annum is payable for each of two children maintained outside Sierra Leone. Free passages for the officer, his wife and up to two children under 19 years of age. Government quarters if available. Generous leave. Free medical attention. Low income tax.

Candidates should be between 30 and 40 years of age, must hold a Degree in Agricultural Engineering or have passed or be exempt from Parts I and II of the examination for A.M.I.Mech.E., and have at least two years' subsequent practical experience.

Write, Director of Recruitment, Colonial Office, London, S.W.1, stating age, qualifications and experience. Quote BCD 63/15/017. E6883

A.E.R.E.

HARWELL

REACTOR ENGINEERS

Two vacancies are available to qualified engineers for :

(a) Operations Group—operation on shift of Experimental High Flux Reactors.
(b) Design, development and commissioning of circulative systems (loops) which are tested in the Experimental Reactors.

Both posts give excellent opportunity to gain experience in advanced reactor engineering.

Engineers with good academic qualifications, aged 25–35, are sought. Salary : £825–£1740, according to age, qualifications and experience.

Send postcard for full details to Group Recruitment Officer (1079/25), A.E.R.E., Didcot, Berks. E6808

DURHAM COUNTY WATER BOARD

APPOINTMENTS

Appointment of ENGINEERING ASSISTANT. "Special Scale" (£750 to £1030 per annum). (Must be Corporate Member, Inst. Mech.E.)

Appointment of GENERAL PLANT FOREMAN. Miscellaneous Grade VI (£645 to £725 per annum). (Housing available for this post if required.)

Particulars and application forms may be obtained from A. C. Wildsmith, M.I.C.E., M.I.W.E., Chief Engineer, Neville Court Durham, and completed forms must reach the undersigned not later than noon, Monday, 28th April, 1958.

Canvassing, in any form, will disqualify.

C. GIBSON,
Clerk to the Board.
43, Old Elvet,
Durham,
1st April, 1958. E6763

NATIONAL COAL BOARD

PRODUCTION DEPARTMENT

METHOD STUDY ENGINEERS

METHOD STUDY ENGINEERS required by N.C.B.'s Production Department in London. Duties include assisting in the introduction of Method Study techniques and lecturing on training courses, and involve some travelling. Professional engineering qualifications required, preferably in coal mining, although mechanical, electrical and metalliferous mining engineers will be considered. Method study experience, though not essential, is very desirable, but training will be given to otherwise suitable candidates lacking this experience. Appointment (superannuable) according to qualifications and experience, within inclusive range £1350 to £1964. Write to Staff Dept. (X1116), National Coal Board, Hobart House, London, S.W.1, for application form, which must be returned by 30th April, 1958. E6815

ROYAL NAVAL SCIENTIFIC SERVICE

APPOINTMENTS

Royal Naval Scientific Service requires PHYSICISTS, ELECTRONIC ENGINEERS and MATHEMATICIANS for 25 Senior Scientific and Scientific Officer posts at establishments in London area, Baldock, Harwell, Haslemere, Poole, Greenock and Rosyth. Also required : MECHANICAL ENGINEER for work on heat transfer problems at Harwell ; MECHANICAL ENGINEER for work on fuel and lubricating oil problems in London area ; MECHANICAL ENGINEER for work on gas turbine and problems in London area ; CHEMICAL ENGINEERS for London area and Poole ; METALLURGISTS for Rosyth and Poole ; CHEMISTS (Physical and Inorganic) for Poole and Baldock. Candidates must normally be natural born British subjects of natural born British parents, with at least First or Second Class Honours Degrees or equivalent high professional attainments. S.S.O.s must have had at least three years' post-graduate experience and be 26 years of age. Salaries (men), S.S.O., £1190–£1410 ; S.O., £635–£1110 (London)—somewhat lower in provinces. Appointments are unestablished (with F.S.S.U. benefits), but opportunities may occur for those under 32 to compete for established posts.—Forms from M.L.N.S., Technical and Scientific Register (K), 26, King Street, London, S.W.1, quoting A.98/8/A. E6550

PUBLIC APPOINTMENTS

MANCHESTER CORPORATION WATERWORKS

ASSISTANT ENGINEERS (CLASS III)

Applications are invited for the undermentioned engineering appointments on the temporary staff of the Corporation in connection with the design and execution of works included in (a) the Third and Fourth Instalments of the Haweswater Scheme, including the laying of 54in dia. steel pipes, and the construction of two service reservoirs (200 million gallons capacity), near Bury, Lancs, and (b) the filtration and treatment of the Longdendale supply :

ASSISTANT ENGINEERS (CLASS III). Salary in the range of £575/£845 p.a., according to qualifications and experience.

Applications, stating (1) age, (2) education and training, (3) professional qualifications, (4) experience in the preparation of plans and construction of waterworks or other civil engineering works, together with the names of two referees, should be addressed to the Engineer and Manager, Waterworks Offices, Town Hall, Manchester, 2, so as to be received by 10th May, 1958. E6864

MIDDLESEX COUNTY COUNCIL

COUNTY ARCHITECT'S DEPARTMENT

SENIOR ENGINEERING ASSISTANT

SENIOR ENGINEERING ASSISTANT required in County Architect's Department, for preparation of schemes for the heating of large County Buildings. A.P.T. III, £845–£1025 per annum, plus £30 London Weighting (if 26 years or over). Established, subject to medical fitness. Prescribed conditions. 5-day week.

Application forms (stamped, addressed envelope) from County Architect, 1, Queen Anne's Gate Buildings, Dartmouth Street, S.W.1, returnable by 31st May. (Quote X.297E.) Canvassing disqualifies. E6881

TOOTING BEC HOSPITAL

LONDON, S.W.17

SENIOR ENGINEER

SENIOR ENGINEER required for duty at Tooting Bec Hospital, London, S.W.17. Applicants, who must live within easy reach of the Hospital, should have a sound knowledge of the maintenance and operation of the engineering services of a large hospital, including both mechanical and electrical, and must possess approved qualifications.

Salary : £740, rising to £880 a year, plus London Weighting (£20 per annum, age 21–25, £30 per annum age 26 and over).

Applications, giving full particulars and names of two referees, should reach the Group Secretary at the above address by 2nd May, 1958. E6829

CITY OF BIRMINGHAM WATER DEPARTMENT

ASSISTANT ENGINEER, NEW WORKS AND CONTRACTS

Applications are invited for the above appointment. Salary range £595–£1030 per annum, according to qualifications and experience. Post pensionable—medical examination. Canvassing disqualifies.

Application forms and further particulars from General Manager and Secretary, Water Department, Council House, Birmingham, 3, returnable by 7th May, 1958. E6880

UNIVERSITY OF NOTTINGHAM

APPOINTMENT OF SENIOR LECTURER OR LECTURER IN PRODUCTION ENGINEERING

Applications are invited for the above appointment in the Mechanical Engineering Department. The Lecturer will be responsible for the development of lecture courses and research in Production Engineering and manufacturing processes. Applicants should have a good Engineering Degree and industrial experience in both engineering design and production. Research facilities will be available, and experience in research and in the planning of research though not essential, is desirable. Salary scales : Senior Lecturer, £1650 to £1950 ; Lecturer, £900 to £1650 ; Universities Superannuation Scheme and family allowances. Conditions of appointment and form of application, which should be returned by Monday, 19th May, from the Registrar.

E6842

TENDERS

TENDERS are invited for the SUPPLY and FITTING of THREE HIGH-PRESSURE AUTOCLAVES and STERILISATION SUITES, in the first instance, in operating theatres at Dudley Road Hospital. It should be noted that a further Three High-Pressure Autoclaves and Sterlisation Suites will eventually be required.

Forms of Tender and specification may be obtained from the Group Secretary, Dudley Road Hospital, Birmingham, 18. E6865

TENDERS

INDIA STORE DEPARTMENT

AXLEBOX GUARD GROOVE LINERS, MANGANESE STEEL

The Director General of India Store Department, Government Building, Bromyard Avenue, Acton, London, W.3, invites TENDERS for the SUPPLY of:

	Quantity, Nos.
AXLEBOX GUARD GROOVE LINERS, MANGANESE STEEL...	26,156

Forms of Tender may be obtained from the above address on or after the 18th April, 1958, at a fee of 10s., which is not returnable. If payment is made by cheque, it should please be made payable to "High Commissioner for India." Tenders are to be delivered by 2 p.m. on Thursday, 29th May, 1958.

Please quote reference No. 135/57/RLY. E6859

DAMODAR VALLEY CORPORATION

The Office of the "Damodar Valley Corporation," Anderson House, Alipore, Calcutta–27, India, invites TENDERS for the following :—

(a) D.V.C. Tender enquiry No. PE-SPEC. 45 : for SUPPLY of VALVES and SPECIALITIES for the complete installation of three 75/82·5 megawatt turbo-generators and three 730/750,000 lb per hour 1500 p.s.i.g., 1005 deg. F. steam generators, with accessories and services, for D.V.C. Durgapur Thermal Power Station and Bokaro 4th Unit.

(b) D.V.C. Tender enquiry No. PE-SPEC. 47 : for SUPPLY of COMPLETE COAL-CONVEYING SYSTEM for D.V.C. Bermo Coal Colliery, to handle both coal and washed coal middlings. Average size of coal about 8in., average size of washed coal middlings about 3in.

Specifications, drawings, &c., relative to the above can be purchased direct from the Damodar Valley Corporation, Anderson House, Alipore, Calcutta–27, India, at 15s. per copy for Spec. 47, and £7 10s. per copy for Spec. 45, plus £1 17s. 6d. for air parcel charges for Spec. 47, and £7 2s. 6d. for air parcel charges for Spec. 45. Tenders are to returned direct to Damodar Valley Corporation at the above address, to reach them by 3 p.m. on 28th April, for Spec. 47, and 3 p.m. on 8th May, for Spec. 45.

Specimen copies of the above specifications are on view at "India Store Department," Government Building, Bromyard Avenue, Acton, London, W.3, under references S.5361/57/AVH/ENG2, and S.3003/58/AVH/ENG2. E6861

INDIA STORE DEPARTMENT

TURRET LATHES

The Director General, India Store Department, Government Building, Bromyard Avenue, Acton, London, W.3, invites TENDERS for the SUPPLY of:

TURRET LATHES, both Hexagon and Drum Types, 70mm and 65mm—7 off.

The Tender forms, with schedules and specifications, which are returnable on Thursday, the 8th May, 1958, may be obtained from the above office (C.D.N. Branch), on payment of a fee (which is not refundable) of ten shillings for each Tender. The applications for Tenders should clearly state the reference numbers of the Tenders required.—18048/GNK/HAL.

E6860

BEDFORD RURAL DISTRICT COUNCIL

EATON SOCON DRAINAGE

PUMPING PLANT : CONTRACT No. 6

TO MANUFACTURERS OF CENTRIFUGAL PUMPING PLANT

The above Council is prepared to receive TENDERS for TWO SETS of ELECTRICALLY DRIVEN, VERTICALLY ARRANGED, UNCHOKEABLE SEWAGE PUMPS, together with Ancillary Equipment. Each pump shall be capable of a duty of 190 gallons per minute against a total head of 45ft., all in accordance with the specification and drawings prepared by the Engineers, Messrs. John Taylor and Sons, Artillery House, Artillery Row, Victoria Street, Westminster, S.W.1.

Copies of the specification and drawings may be obtained from the offices of the Engineers upon payment of £5 (cheque only, made payable to the Council), which will be returned on receipt of a bona-fide Tender not subsequently withdrawn. The contract documents may be inspected at the offices of either the Engineers or the Council.

Tenders, in plain sealed envelopes, endorsed "Tender—Pumping Plant—Contract No. 6," are to be delivered to my office on or before noon on the 2nd June, 1958.

The council does not bind itself to accept the lowest or any Tender.

(Signed) C. B. TOWNSEND,
Clerk of the Council.
Council Chambers,
41/43, Goldington Road,
Bedford. E6878

INDIA STORE DEPARTMENT

The Director General, India Store Department, Government Building, Bromyard Avenue, Acton, London, W.3, invites TENDERS for the SUPPLY of:

(a) Whirlblaster TROUGH CONVEYOR BELT DRUM—1 off—centrifugal capacity 150 kgs./min. of abrasive ; effective volume 0·75 cu. metres ; motor driven.

(b) ROTARY TABLE SHOT PEENING MACHINE—1 off—airless projection ; total weight 1500 kgs. ; motor driven.

The Tender forms, with schedules and specifications, which are returnable on Thursday, the 8th May, 1958, may be obtained from the above office (C.D.N. Branch) on payment of a fee (which is not refundable) of ten shillings for each Tender. The applications for Tenders should clearly state the reference numbers of the Tenders required, 18044/1957.

E6871

Classified Advts. continued on page 120

EDUCATIONAL

UNIVERSITY OF LONDON

A LECTURE entitled " SOME AUTOMATA OF THE EIGHTEENTH CENTURY " (with numerous coloured-slide illustrations), will be delivered by Dr. H. Zemanek (Vienna) at 5.30 p.m. on 28th April, at the Royal College of Science (Main Chemistry Theatre), Imperial College of Science and Technology, Prince Consort Road, S.W.7.

Admission Free, without ticket.

JAMES HENDERSON,
Academic Registrar.
E6807 E

TECHNICAL HOME STUDY COURSES

For A.M.I.Mech.E.,
A.M.I.Chem.E., A.M.I.M.I.,
A.F.R.Ae.S., C. & G., &c.

OVER 50 FIRST PLACES and more than 2000 Passes have been secured by T.I.G.B. Students at Professional Engineering Examinations. We have a wide range of exclusive Home Study Courses in all branches of Engineering—Mechanical, Electrical, Aeronautical, Automobile, Chemical, Gas, Radio, and Television, Draughtsmanship, &c. Textbooks, blueprints, &c., are provided and, if desired, fees may be paid by moderate instalments.—Write (stating subject of interest) for copy of 110-page Prospectus FREE and without obligation.

THE TECHNOLOGICAL INSTITUTE OF GREAT BRITAIN
(Dept. 76),
29, WRIGHT'S LANE, LONDON, W.8.
E102 E

A.M.I.MECH.E., B.Sc., City and Guilds, &c. Guarantee Postal Courses for all Exams., and Technical Divisions from Elementary to Degree standard. Approximately 95 per cent. successes. 144-page prospectus free on request.—B.I.E.T. (Dept. 22), 29, Wright's Lane, London, W.8. E721 E

FREE! Brochure giving details of Courses in Mechanical and Production Engineering, Draughtsmanship, &c., for the A.M.I.Mech.E., A.M.I.P.E., City and Guilds and other professional examinations. —E.M.I. Institutes, Dept. E.30, London, W.4. (Associated with H.M.V. E972 E

SITUATIONS VACANT

APPLICANTS ARE ADVISED TO SEND COPIES, NOT ORIGINALS, OF THEIR TESTIMONIALS UNLESS OTHERWISE REQUESTED

A LARGE INDUSTRIAL ORGANISATION has vacancies for qualified MECHANICAL ENGINEERS, aged 30–35, with good social and educational background, to train as specialists, finally to take charge of staffs in various industrial areas in this country. Reply, stating full details of age, qualifications and experience.—BOX No. E6754, " The Engineer." A

AS PART OF ITS EXECUTIVE DEVELOPMENT PROGRAMME, a well-known company is seeking a young man of ability. He will initially receive full training in work study and will then be engaged in the application of these techniques throughout the company. Subsequent promotion to management will be based upon his performance in the various assignments given him during this period. The successful candidate will possess H.N.C. or equivalent qualification in Engineering, and be aged 22–26 years. The advertisers are prepared to wait in order to obtain a man of suitable calibre. Please send full details in confidence to Personnel Manager.—BOX No. E6835, " The Engineer." A

A. BOAKE, ROBERTS AND CO., LTD., Chemicals Manufacturers, require :

A MECHANICAL ENGINEER, aged 24–30. Minimum qualification H.N.C. The position is in the department of the Works Engineer, who is responsible for the construction and maintenance of chemical plant and for the operation of all services.

AN INSTRUMENT ENGINEER, aged 21–30. Minimum qualification H.N.C. in Mechanical or Electrical Engineering. He is required to assist in the design and implementation of automatic process control systems. Experience in the chemical or petroleum industry would be an advantage.

Salary for both positions, according to age and qualifications, up to £1200. Contributory pension scheme.—Please apply to the Staff Manager, 100, Carpenters Road, London, E.15. E6872 A

C.I.C. ENGINEERING LIMITED, STREET, SOMERSET, require a TECHNICAL ASSISTANT, to be responsible for progressing and co-ordinating work carried out under Government and Industrial Development Contracts. He will have to deal with Government forms and procedures and submit progress reports periodically. He will be directly responsible to the Managing Director. Applicants who have had experience in one or more of the following : shoemaking, engineering, rubber technology or chemistry, and can produce examples of written work, will be preferred. Age 24–36. Salary range £800 to £1000, depending on age and experience —Please write to the Personnel Department (MSM), marking your application " Private." E1798 A

CHIEF DRAUGHTSMAN required for small D.O. of structural and platework engineers. Experience in design of industrial buildings, conveyor gantries, elevators and chutes, coupled with some knowledge of estimating and ability to deal with clients is essential. The position is suitable for a Senior Draughtsman seeking promotion and a planned expansion programme provides real future opportunities. Minimum qualifications H.N.C. Applicants should give age, qualifications, experience, previous employment and salary.—T. Darnell and Sons, Ltd., Colwick Estate, Colwick, Nottingham. E1775 A

DESIGN/CHECKER STRUCTURAL AND MECHANICAL DRAUGHTSMEN required, South West England. Good conditions, pension scheme.—Apply in confidence to BOX No. E6760, " The Engineer." A

DESIGN DRAUGHTSMEN required, for industrial building work, &c. H.N.C. or A.R.I.B.A. standard. Good conditions, pension scheme.—Apply in confidence to BOX No. E6759, " The Engineer." A

SITUATIONS VACANT

CHEMICAL ENGINEER

A chief Chemical Engineer is required for the central engineering division of a group of companies operating in the heavy chemical industry. Candidates should have a Degree or equivalent in Chemical Engineering and experience in the translation of pilot plant into large scale practice. A good knowledge of all the usual unit operations and ability to prepare complex flow sheets is essential. Candidates should be accustomed to calculating and assessing the economics in new processes and process methods. The position will carry a good salary and membership of the company's pension fund, and consideration will be given to financial assistance towards removal expenses and house purchase if necessary. Applications, which will be treated in the strictest confidence, should quote Ref. CH/TE2/9, and state details of previous experience, positions held and present position and salary.—Write, BOX TE.254, c/o 191, Gresham House, E.C.2. E6845 A

CHIEF PRODUCTION ENGINEER

required by W. H. Allen Sons & Co., Ltd., Atlas Works, Pershore, Worcs, manufacturers of light and medium-size precision gearboxes. Post carries responsibility for work study, jig and tool design, plant layout and process planning. Applicants must be established Work Study Engineers with a sound, practical background and technical training to H.N.C. in Production Engineering or equivalent. Good superannuation scheme and conditions. Successful applicant would be assisted in the removal of household effects to district concerned, in which housing accommodation will be available.—Apply (in confidence), stating experience, positions held and salary range, to the Personnel Manager at the above address. E6845 A

CHIEF TECHNICIAN, for development work on heat exchanger projects and liaison with customers. Applicants, with Degree or H.N.C., must be of mature experience with sound heat transfer background and accustomed to negotiation at all levels. Write, giving details of qualifications, experience, &c., to BOX No. E6855, " The Engineer." A

DESIGNER-DRAUGHTSMEN, age 26–40, for work on fuel injection equipment, for high-speed diesel engines, preferably with H.N.C. and at least 5 years' drawing-office experience on injection or other hydraulic equipment. Vacancies are in the North London area, and full details, together with an indication of salary required, should be sent to BOX No. E6786, " The Engineer." A

DESIGNER ENGINEER required to understudy Chief Designer. Candidates must have H.N.C. in Mechanical Engineering, considerable design experience on lifts or special-purpose equipment, practical machine shop and preferably in addition fabrication and light structure experience. The position offers excellent prospects of advancement, and a good salary is envisaged for suitable applicant. Bonus and pension scheme in operation. Five-day week.—Applications, stating age, qualifications, experience, present position and salary, should be forwarded to Marryat and Scott, Limited, Wellington Works, Hounslow. E1804 A

DRAUGHTSMAN, experienced fans—dust collectors, fume and dust extraction, &c. Capable of preparing schemes and working on own initiative.—Details of age, education, experience and salary to the Secretary, Prat-Daniel (Stanmore), Ltd., Whitecroft, Nailsworth, Stroud, Glos. E1797 A

ELECTRICAL DRAUGHTSMEN required, H.N.C. standard. Fully conversant with motor control gear, A.C. and D.C. E.H.T. and L.T. lighting schemes, &c Good conditions, pension scheme.—Apply in confidence to BOX No. E6757, " The Engineer." A

ENGINEER
required in
DEVELOPMENT LABORATORIES

for stress analysis and vibration problems.

Applicants should have a good Degree in Mechanical Engineering, together with ability to make a mathematical approach to problems. Some experience in industry and in the use of electronic equipment is desirable.

The position carries an attractive starting salary and provides excellent opportunities for further advancement. Staff pension fund.

Apply in writing, stating age, qualifications and experience, to the Personnel Manager, JOSEPH LUCAS (ELECTRICAL), LIMITED, Great King Street, Birmingham, 19, quoting reference PM/D/192. E996 A

ENGINEER/DRAUGHTSMAN for Senior position. Experienced chemical and mechanical engineering, prepared to travel occasionally on plant operation and progressing. Also organisation draughting and estimating departments small London office. Preferably with knowledge of scrubbing towers, air circuits, cyclone and van design. Some training in chemistry would be an advantage. Excellent opportunity with suitable remuneration. Particulars, including indication salary required.—BOX No. E1811, " The Engineer." A

SITUATIONS VACANT

ENGINEERING DRAUGHTSMAN, experienced in all aspects of services layout. Work in connection with the modernisation and replacement of services equipment in a large institution. Duties entail a thorough knowledge of steam, hot water, air distribution and associated equipment. Salary will depend on experience and qualifications, but it is expected to be in the range £750–£1000 p.a.—Applications, giving details of training, experience and qualifications, to BOX No. 1646, c/o Charles Barker and Sons, Ltd., Gateway House, London, E.C.4. E6839 A

ENGINEERING MODELS —DESIGN ENGINEER

An opportunity exists in the Design Office of a heavy chemical manufacturing organisation based in London for a suitably experienced Designer to control and operate the application of engineering models to the design of chemical process plant. Applicants should have chemical or refinery drawing-office experience (preferably in piping and plant layout) and be conversant with the techniques of using models as an aid to design. A well-equipped model shop has been set up and the position offers good prospects with considerable responsibility. The position will carry a good salary, and membership of the company's pension fund. Applications, which will be treated in the strictest confidence, should quote Ref. CH/TE2/10, and state details of previous experience, positions held and present position and salary.—Write BOX TE.258, c/o 191, Gresham House, E.C.2. E6862 A

ESTIMATING ENGINEER required for medium/heavy Engineering Works, West Middlesex area Knowledge of Gear Transmission essential. Write, stating age and giving full particulars of qualifications and experience and salary required.—BOX No. E6736, " The Engineer." A

ESTIMATOR for progressive position with prominent London firm of Land and Marine Boiler Engineers. Drawing-office experience essential ; workshop experience an advantage. Attractive salary commensurate with experience and qualifications. Write fully, stating age, &c.—BOX No. 1645/SE2, c/o Charles Barker and Sons, Ltd., Gateway House, London, E.C.4. E6840 A

ESTIMATOR REQUIRED in the Engineering Division of British Cellophane, Ltd., Bridgwater, Somerset. Applicants must have served a general engineering apprenticeship, followed by drawing-office experience, and should hold at least an Ordinary National Certificate in Mechanical Engineering ; those with suitable background, but without experience of estimating, would be considered for training. The duties comprise estimating from drawings or from site inspection of the material and labour required for the execution of work on both maintenance and new construction of plant in a chemical factory.—Applications, quoting ref. No. E83 Er., should be addressed to the Personnel Officer. E6703 A

EXPERIENCED DRAUGHTSMEN of O.N.C. or H.N.C. standard required for interesting design work on process plant and machinery. A good technical background and knowledge of machine design is essential and applicants should be qualified to H.N.C. standard. Salaries are assessed in accordance with age, qualifications and experience and will be reviewed annually. Contributory superannuation and widows' pension fund are in operation and there are excellent canteen, welfare and recreational facilities.—Applicants should apply in writing to Group Personnel Department, Pilkington Brothers Limited, Grove Street, St. Helens, enclosing a brief history of their career and details of their education and qualifications. E6814 A

EXPERIENCED FOREMAN BLACKSMITH required by large Midlands steelworks. Good general smithing experience is essential and some knowledge of modern chain welding practice would be desirable. This is a staff position with contributory superannuation and life assurance benefits. Please apply, giving details of past experience, age and salary required.—BOX No. E6833, " The Engineer." A

EXPERIENCED FOREMAN PIPE FITTER required for a large Midlands steelworks. Knowledge of installation and maintenance of all services is essential, together with experience of modern pipe-bending and welding techniques. This is a staff position with contributory superannuation and life assurance benefits. Please apply, giving details of past experience, age and salary required.—BOX No. E6834, " The Engineer." A

FORENSIC ENGINEERS invite application from ENGINEERING GRADUATES with good background and industrial experience, for responsible and individualistic post. Age about 30 years.—BOX No. E6766, " The Engineer." A

INSULATION ENGINEER

required for service in India on a three-year contract (initially) with a European managed firm. Practical experience in hot and cold insulation, ability to prepare estimates and to take charge of an Insulation contract department essential. Good salary with Provident Fund offered to suitable candidate.—Write, BOX Z.H.89, Deacons Advertising, 36, Leadenhall Street, London, E.C.3. E6848 A

MECHANICAL ENGINEER required for Mining Company in WEST AFRICA, as Assistant to Mechanical Superintendent. Age approximately 30/35, with experience of planned maintenance, work study and general workshop practice, preferably of opencast mining and conveying equipment. Commencing salary, £1500 per annum, plus 5 per cent bonus, plus for married man, passage or separation allowance of £10 per month and £5 per month for each child. 15-month tours followed by liberal leave on full salary in U.K. Return passage paid. Free furnished quarters and medical attention. Contributory pension scheme with retirement at age 55. Life assurance and dependants income schemes.—Write, giving full details, experience, stating age, married or single, to SIERRA LEONE DEVELOPMENT CO., LTD., Dept. ME6, City-Gate House, Finsbury Square, E.C.2. E6863 A

SITUATIONS VACANT

JACKSON BROS. OF KNOTTINGLEY, LTD.,

require the following :—

1. Young ENGINEER, for maintenance and development work in a modern glass container works. The post is permanent and pensionable and offers scope for further training and advancement. Previous experience in a glass works is not necessary, but successful applicants must have served an engineering apprenticeship, must be either Graduate Members of the I.Mech.E., or studying for this qualification and have had some experience in general works maintenance. Preference will be given to applicants with a knowledge of modern machine shop practice and/or automatic machinery maintenance.
2. SENIOR DRAUGHTSMAN, for work on the design of plant and process equipment in modern glass-producing factory. Previous glass works experience not essential. The applicant should be capable of eventually taking charge of a small drawing-office. State salary required.

All applications should be addressed to Personnel Manager, Jackson Bros. (of Knottingley), Ltd., P.O. Box No. 2, Knottingley, Yorkshire. E6774 A

LABOUR OFFICER required, to control labour requirements for large-scale engineering project in the North of England. Applicant should have extensive experience in the recruitment and handling of labour engaged in mechanical installation work, and should be familiar with trade union procedure.—Write, giving details of age, experience to date and salary required, to : British Oxygen Wimpey, Ltd., (M. & E.), Spadeadam Research Establishment, Near Gilsland, Cumberland. E6856 A

JOSEPH LUCAS (ELECTRICAL), LIMITED,

have vacancies for

ASSISTANT DEVELOPMENT ENGINEERS

to work on the design and development of automobile generators, alternators and starting motors and also of motor-cycle electrical equipment, including equipment to be used for racing purposes. Applicants should be of Higher National standard and should have had previous experience in electrical design. Five-day week, staff pension fund.

Apply in writing, stating age, qualifications and experience, to the PERSONNEL MANAGER, JOSEPH LUCAS (ELECTRICAL), LIMITED, Great King Street, Birmingham, 19, quoting reference PM/D/176. E995 A

MECHANICAL DESIGN ENGINEER

The Associated Ethyl Company, Limited, has a vacancy in the Engineering Department located at Ellesmere Port, Cheshire.

The successful candidate will be engaged on the design of chemical plants and their associated services for several factories operated by the company in various parts of the country.

He will be responsible for preparing design instructions to the drawing-office, and will require to liaise with the civil, electrical, instrument, estimating and construction sections of the engineering department. His duties will also involve the preparation of purchasing specifications for mechanical plant and subsequent negotiations with contractors.

Applicants should have served a recognised trade apprenticeship, followed by drawing-office experience, and be a Corporate Member of the Institution of Mechanical Engineers. Whilst not essential, experience in the heavy chemical, process, or power plant industries would be an advantage.

This is a permanent position and offers opportunities for advancement to a man of initiative. Salary will be in accordance with age, qualifications and experience and some assistance may be given to a married man towards helping him change his location.

Applications should be sent to :
Manager, Staff and Training Department,
The Associated Ethyl Company, Limited,
Ellesmere Port,
Cheshire. E6876 A

MECHANICAL ENGINEER

Owing to Company expansion, an Engineer is needed in the new Bessemer Plant to cover co-ordination of all engineering maintenance. This oxygen steam blowing plant is the first of its kind in the U.K.

Applications are invited from Engineers who have experience in installation and maintenance of E.O.T. Cranes and Blowing Plant.

Experience in Bessemer or Steel making plant maintenance will be an advantage.

Candidates should have their Higher National Certificate in Mechanical Engineering or its equivalent.

Those wishing to apply should write, giving full details of age, experience, present salary and any further information considered relevant, to :—

Superintendent, Personnel Services,
THE STEEL COMPANY OF WALES, LTD.,
Abbey Works,
PORT TALBOT, Glam. E6873 A

MECHANICAL/PIPING DRAUGHTSMEN required, H.N.C. standard. Good conditions, pension scheme.—Apply in confidence to BOX No. E6758, " The Engineer." A

OLD-ESTABLISHED ENGINEERING CONCERN manufacturing steam specialities, seek active TECHNICAL REPRESENTATIVE to develop country-wide sales in allied and new fields. Practical engineering experience essential, coupled with real ability to create new business. Good starting salary, car and expenses offered initially, further progress depending entirely on the candidate's own ability and initiative.—BOX No. E1763, " The Engineer." A

SITUATIONS VACANT

NYASALAND FACTORY MANAGER

Nyasaland Oil Industries, Ltd., require an Engineer-Manager, under the age of 45, to administer and operate its cotton seed expressing factory, situated in Blantyre, Nyasaland, 6000 tons capacity, which is now nearing completion.

Applicants with previous experience of managing such a plant will be given preference and would be expected to undertake the necessary laboratory tests on cotton seed and oil.

The salary offered is £1600 by £70 to £1880 per annum, point of entry according to experience. Suitable housing will be provided free. Contract for three years with four months' paid leave on completion.

Applications, in writing, including earliest date available, should be made to BOX No. C1360, c/o White's, Ltd., 72, Fleet Street, E.C.4.

E6882 A

PERSONAL ASSISTANT required for the Chief Engineer of Organisation with interests in Great Britain and on the Continent. Applicants should be Mechanical Engineers between 30 and 40 years of age, preferably University Graduates with general experience of works engineering. They should also be reasonably good draughtsmen, as some design work is involved. Salary will be commensurate with age, experience and qualifications.—Write, to BOX A.213, c/o Streets, 110, Old Broad Street, E.C.2.

E6843 A

QUALIFIED CIVIL ENGINEER, aged 28/35, required for one tour only of approximately 15 months, for supervision of contracts in BRITISH WEST AFRICA. Applicants should have experience of all aspects of contract administration. Salary, £1900 per annum. Guaranteed bonus of 5 per cent. plus for married man, separation allowance of £10 per month and £5 per month for each child under 18. Return passage paid. Initial kit allowance, free furnished quarters and medical attention. Life assurance and dependents' income schemes.—Write, giving full details experience, stating age, married or single, to Sierra Leone Development Co., Ltd., Dept. CE5, City Gate House, Finsbury Square, E.C.2. E6822 A

REINFORCED CONCRETE DESIGNERS AND DRAUGHTSMEN are required by large organisation to work in Dorset, South Wales or Manchester areas. Applicants must have sound experience. Salary will be high, together with an expenses allowance if coming from outside the district. Superannuation, excellent conditions.—Apply, giving full particulars of experience and qualifications, to BOX No. E6717, "The Engineer." quoting M.D.I.R. A

ROLL DESIGNER, aged 30–45, required for large steelworks in the Midlands, with expansion scheme in progress. Previous experience of small sections desirable. Staff position, pension and free life assurance schemes in operation. Full details of age, qualifications and experience.—BOX No. E6832, "The Engineer." A

SALES ENGINEER required by Yorkshire manufacturer of heavy industrial gears. Must be technically trained at least up to H.N.C. standard. Excellent opportunity for a man with drive, initiative and the right experience. Write, with full details of past career and required salary.—BOX No. E1768, "The Engineer." A

SECTION LEADER ELECTRICAL DRAUGHTSMAN and Senior DRAUGHTSMAN required for section handling varied projects, including large plant installations. Section Leader post is a senior staff appointment. Salary commensurate with experience. Interviews arranged to suit applicant.—Write or telephone to Chief Draughtsman, General Engineering Department, Northern Aluminium Company Limited, Rogerstone, Mon. (telephone, Newport 59991/6). E6810 A

SALES ENGINEER required for Induction Heating Section of Birlec, Ltd. Some experience of induction heating desirable; electrical and general engineering knowledge essential. Duties involve tendering and correspondence combined with some customer contact.—Apply in writing, stating experience and present salary, to Personnel Manager (H/JMP), Birlec, Ltd., Tyburn Road, Birmingham, 24. E6868 A

SECTION LEADER DRAUGHTSMAN required. Experience—sound mechanical engineering and live loaded structures. Supervision of senior and junior draughtsmen. H.N.C. minimum; 30/35 age group. Conscientious, unafraid of work, responsibility and a strict disciplinarian. Full welfare services available.—Write, BOX 562, Erwoods Ltd., 211, Piccadilly, W.1. E6852 A

SENIOR DESIGN DRAUGHTSMEN required for interestiug work on mechanical engineering projects. Knowledge of hydraulics an advantage.—Chamberlain Industries, Ltd., Staffa Road, Leyton, E.10 (Ley 3678). E6782 A

SENIOR DESIGNERS.—Applications are invited from Senior Designers, experienced in all types of electric cranes, for important work in connection with steel works development schemes. Salaries will be commensurate with responsibilities, and only men of good structural and mechanical training are required.—Write, giving details of age, experience and salary required, to The General Manager, The Wellman Smith Owen Engineering Corporation, Ltd., Darlaston, South Staffs. E6708 A

SENIOR DRAUGHTSMAN required. Medium/heavy engineering experience preferred. Capable of preparing schemes on own initiative. West Middlesex area. Write, stating age and giving full particulars of qualifications, experience and salary required.—BOX No. E6737, "The Engineer." A

SENIOR DRAUGHTSMAN required, for Jig and Tool and Special Machine Tool Design in connection with the mass production of crankshafts. Good salary and attractive conditions of employment.—Reply, with details of age and experience, to Personnel Manager, Ambrose Shardlow and Co., Ltd., Ealing Works, Meadow Hall, Sheffield, 9. E1800 A

SENIOR MECHANICAL ENGINEERING DRAUGHTSMAN required for plant layout and design. General engineering experience desired. Knowledge of rolling mills, conveyors, mechanical handling or furnaces, would be advantageous. Salary commensurate with experience. Interviews arranged to suit applicant.—Write or telephone to Chief Draughtsman, General Engineering Department, Northern Aluminium Company Limited, Rogerstone, Mon. (telephone, Newport 59991/6). E6813 A

SENIOR STRUCTURAL DESIGNER OR ARCHITECTURAL DRAUGHTSMAN with experience in reinforced concrete design, required for plant installations, industrial buildings and offices. Salary over £900, according to experience. Interviews arranged to suit applicant.—Write or telephone to Chief Draughtsman, General Engineering Department, Northern Aluminium Company Limited, Rogerstone, Mon. (telephone, Newport 59991/6). E6812 A

STRUCTURAL DESIGNERS, DETAILERS and DRAUGHTSMEN with good design experience, are required for a range of appointments offering scope to both qualified men and those who are studying for future qualifications. The work is mainly concerned with varied and interesting reinforced concrete design but some experience of structural steelwork would be an advantage. The posts are at Head Office and those who are interested should apply to:

Personnel Manager (D.D.I),
John Laing and Son Limited,
London, N.W.7. E6818 A

SITE ENGINEER required for supervision of mechanical and instrumentation work on a large-scale project in the North of England. Duties will include organisation and supervision of direct labour and sub-contractors. Applicants should preferably be Corporate Members of a Senior Institution and have appreciable experience in one or both of the above fields of work.—Write, giving details of age, experience to date and salary required, to British Oxygen Wimpey, Ltd. (M. and E.), Spadeadam Research Establishment, Near Gilsland, Cumberland. E6857 A

STRUCTURAL DESIGNERS, Senior and Junior, required for busy London office handling wide variety building schemes. Considerable scope for advancement available to men of initiative. Consideration given to holiday arrangements.—BOX No E1782, "The Engineer." A

STRUCTURAL DRAUGHTSMAN, with design experience, to take charge of small drawing-office and act as Technical Assistant to Manager in Structural Works, South of London. Pension scheme in operation. Reply, stating age, experience and salary required.—BOX No. E1810, "The Engineer." A

STRUCTURAL ENGINEERS

Firm of repute, with extensive fabricated steelwork contracts in hand, of versatile nature, have vacancy for ASSISTANT TO MANAGER. Live and ambitious young man wanted who must have undoubted experience and be capable negotiator in all commercial and organising matters in the trade. Technical knowledge valuable asset, but stress laid on ability ensure co-operation and efficiency general operation of business. Four-figure salary; pensionable; North West Manchester area. Age limit preferred 35, but others considered if ability warrants. Full history details, present employment and status, with proof experience, in confidence. —BOX No. E1786, "The Engineer." A

THE G.K.N. GROUP RESEARCH LABORATORY requires a PHYSICIST or METALLURGIST, preferably with electrical experience, to control projects in the welding field. The post requires a capacity for original work and the exercise of initiative.

The Laboratory serves all the companies of a large group, and is well equipped for fundamental research and development. Ample opportunity exists for contact with Group companies, and research activities are extending.

Applicants, who should be of Degree standard, are assured of good working conditions. Salary scales are attractive.—Please write to the Director of Research, G.K.N. Group Research Laboratory, Birmingham New Road, Lanesfield, Wolverhampton, quoting reference EE/W/4. E6777 A

THE UNITED GLASS BOTTLE MANUFACTURERS, LTD., St. Helens, Northern Division Design Office.

DESIGN DRAUGHTSMEN, MECHANICAL, required. Senior and Junior, with experience in the design and detail design of Medium Heavy Special Purpose Machines and devices. Experience an advantage in the Manufacture of Glass Containers and special ware. Pension scheme in operation.—Applications, giving details of previous experience and qualifications, to the Personnel Officer, Sherdley Works, St. Helens, Lancs. E6846 A

TECHNICAL WRITER—experienced in the preparation of instruction books, is required for Technical Publications Department of a West London Company actively engaged in producing a wide range of specialised chemical plant. Write, stating age, experience and salary required.—BOX No. E6869, "The Engineer." A

TONGUE-TIED TECHNICIANS need experienced help when applying for jobs. DRAFTING, ADVICE ON INTERVIEWS, &c. Make the best of yourself and increase your chances.—BOX No. E1780, "The Engineer." A

TRANSLATORS accustomed to handling difficult German texts, are invited to contact Brunton Technical Translations, Charlotten-Str., 47, Dusseldorf, Germany. Must be able to write good English. Please state subjects handled and fees required. E6854 A

YOUNG METALLURGIST, age 25–30, with H.N.C. or L.I.M. preferred, required by engineering company in South Manchester area, to take charge of laboratories now in course of erection. This appointment offers development work over a broad field and carries excellent superannuation scheme, sports and social facilities and staff canteen. Replies in confidence, stating age, qualifications, experience and salary required.—BOX No. E6802, "The Engineer." A

PACKAGING ENGINEER

PFIZER LTD.

invite applications for the position of Packaging Engineer at their Richborough, Sandwich, plant. The successful candidate should have served an Engineering apprenticeship and be conversant with modern packaging practice and its effect on production costs.

The duties of the appointment will involve technical advice on package design, packaging materials and packaging machinery. The development of packaging machinery for specialised purposes will also form a part of the responsibilities of the successful candidate.

A non-contributory pension scheme is in operation. Removal expenses will be paid.

Applications should be made, in writing, to:

Personnel Officer, Pfizer Ltd., 137/139, Sandgate Road, Folkestone,

giving full details of age, experience, salary, &c., and quoting reference E 6662.

E6837 A

DEPUTY CHIEF MECHANICAL ENGINEER

required at the

EBBW VALE SECTION

of

RICHARD THOMAS & BALDWINS LIMITED

Candidates should be between 35 and 50 years of age, and should either have an engineering degree or be a corporate member of the Institution of Mechanical Engineers. Extensive experience in the erection and maintenance of heavy plant, preferably in the steel industry, is an essential qualification. Salary commensurate with qualifications; superannuation scheme.

Applications will be treated as strictly confidential, and should be addressed to the

Chief Engineer,
Richard Thomas and Baldwins, Limited,
Ebbw Vale, Mon.

E6853 A

ASSISTANT SHIFT ENGINEERS

Stewarts and Lloyds, Limited, have vacancies for four Assistant Shift Engineers, to work under the supervision of the present shift engineers in their tonnage oxygen plant at Corby, Northants.

Men of around twenty-five years of age and in possession of Ordinary National Certificates in Mechanical Engineering will receive preference. Usual staff conditions apply, including pension scheme and canteen facilities. Housing position favourable. Please apply, stating age, experience, qualifications and salary expected, to:—

Manager/Personnel,
Stewarts and Lloyds, Limited,
CORBY, Northants. E6828 A

SHELL

THE SHELL PETROLEUM COMPANY LIMITED,

has a vacancy for a

TECHNICAL ASSISTANT

in their

BITUMEN MARKETING ORGANISATION

The successful candidate will specialise in all aspects of the use and marketing of bitumen and after training and experience will be expected to advise technically on applications, particularly in the road and Civil Engineering field.

The work will, in due course, entail travelling and some knowledge of at least one European language will be an advantage.

Candidates should preferably hold a University Degree or Honours Diploma in Civil Engineering but other qualifications will be considered. Age should be in the region 22–30 years. The salary offered will be commensurate with experience and qualifications.

The post should attract a young, qualified graduate with some professional experience, who sees his future in commerce and who is attracted by the scope of an international field for the exercise of his knowledge.

Please apply, in confidence, to

THE SHELL PETROLEUM COMPANY LIMITED,
STAFF DEPARTMENT (R/B)
ST. HELEN'S COURT,
GREAT ST. HELEN'S
LONDON, E.C.3.

E6806 A

BOOKS and PUBLICATIONS

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Classified Advts. continued on page 122

SITUATIONS VACANT

A Company in the West London area invite applications for the post of

POWER HOUSE ENGINEER

The Power House is equipped with both coal-fired and oil-fired W.T. boilers and turbine.

Candidates must have requisite practical and technical experience with ability to control labour and supervise factory steam distribution system, together with air, water and refrigeration services.

The appointment carries good prospects with substantial commencing salary and qualifies for contributory pension and assurance scheme.

Write, stating age, qualifications and positions held.—BOX No. E6820, "The Engineer." A

SITUATIONS VACANT

BABCOCK & WILCOX LIMITED
ATOMIC ENERGY DEPARTMENT

Invite applications for the post of

SENIOR ELECTRICAL ENGINEER

to lead a team engaged on layout, selection and specification of electric equipment for nuclear steam generation plant, covering switchgear, cabling and motors from fractional to several thousand horsepower.

Applicants should be professionally qualified, and have appropriate experience in power station, factory or chemical plant electrical installation design. Some experience of instrumentation would be an advantage.

Write, giving full details of past experience, to:

The Assistant Secretary,
209, Euston Road,
LONDON, N.W.1. E6841 A

SITUATIONS VACANT

TECHNICAL SALES ENGINEER

EXPERIENCED IN INDUSTRIAL FURNACES

This is a senior appointment, offering good salary, pension scheme and working conditions, to applicants with the required qualifications.

Similar previous experience desirable, together with up-to-date knowledge of furnace technology, fuels and steel making practice.

Address replies, in confidence, to General Manager, Furnace Division, The Wellman Smith Owen Engineering Corporation, Ltd., Parnell House, Wilton Road, S.W.1.

E6847 A

SITUATIONS VACANT

DESIGN ENGINEERS

required by progressive company for work in the low-temperature gas separation field. Engineers are required from all branches of chemical engineering, but particularly those experienced in mechanical and piping design. Progressive positions available for the right men. Comprehensive superannuation scheme.— Replies to the Technical Manager, Air Products (Great Britain), Limited, 9, Upper Belgrave Street, S.W.1.

E1779 A

MSL have been retained to advise on the appointment of a

CHIEF ENGINEER

for an international company manufacturing light electro-mechanical equipment and fractional H.P. motors. Turnover runs to several millions and has increased considerably in recent years. The Chief Engineer will advise the Board on technical matters and be fully responsible for development and design through to manufacture. Periodic visits to U.S.A. will be necessary.

Candidates must have a degree in electrical engineering with strong supporting mechanical qualifications. They must show a good record of directing technical teams engaged in the development and design of high speed light electro-mechanical products for manufacture in large batch or flow quantities. Age about 40.

Starting salary up to £4,000 per annum. Location near London.

No information will be disclosed to our clients until candidates know their identity and have given permission after personal discussion. Please send brief details in confidence, quoting reference G. 935, to E. P. Kelsall.

MANAGEMENT SELECTION LIMITED
17, Stratton Street, London, W.1.

E6825 A

NUCLEAR POWER STATIONS

PRESSURE VESSEL ENGINEERS AND DRAUGHTSMEN

Applications are invited for the following appointments in the

ATOMIC ENERGY DIVISION
OF
THE GENERAL ELECTRIC COMPANY LIMITED

1. PRESSURE VESSEL ENGINEERS

Applicants should have design experience on pressure vessels for the refinery or chemical industries, and should be conversant with the various codes of practice. Shop fabrication or site erection experience would be an advantage. Minimum qualifications H.N.C.

Duties would include the development of designs, from initial concept to fabrication stage, of the numerous pressure vessels which are required in this field for power stations and research projects. Some of these vessels are the largest and most complex of their kind and require the careful solution of many novel problems.

2. SENIOR DRAUGHTSMEN

Applicants should be experienced in pressure vessel work, preferably with some design experience. Minimum qualifications O.N.C.

Work involves the preparation and checking of layout and design drawings and the checking of fabrication drawings. The scope of the work is similar to that mentioned in 1. Suitable applicants will be required to undertake a certain amount of design work.

The above posts provide opportunities for advancement in a rapidly expanding industry, and attractive salaries will be offered to suitable applicants.

Applications should be sent to The Personnel Manager (A.E.D.), The General Electric Company, Limited, Erith, Kent. Telephone: ERITH 3011, Extension 200.

Appointments for interview may also be made by telephone, and these may possibly be arranged in London, Manchester, Newcastle or Glasgow. Housing assistance may be given to suitable applicants and removal expenses will be paid. Holiday arrangements already made will be honoured.

E6775 A

EXPERIENCED COMMERCIAL ENGINEER

required for the preparation of Specifications and Tenders for Diesel Electric Power Plants in small to medium range.

A sound knowledge of Engines and Generators is required. The factory is situated in a new Town some 30 miles from London, and assistance can be given towards Housing in the area. Apply in writing, with full details of experience and salary to date, to BOX 4X P 788, A.K. Advg., 212a, Shaftesbury Ave., London, W.C.2.

E6838 A

ASSISTANT MECHANICAL ENGINEERS

required by

SWISS HEAD OFFICE

of Power Plant Manufacturers
for sales and contract division.

Essential requirements are good school education, University Degree or approved Technical College Diploma, and a fair amount of workshop and steam turbine test-bed experience. Some knowledge of the German and/or French language expected. Good salary and pensionable post. Application should contain details of age, education, career to date and salary expected.—BOX No. E1803, "The Engineer." A

PORTASILO

SENIOR DESIGN DRAUGHTSMAN

The leading United Kingdom manufacturers of portable bulk handling and storage equipment invite applications from draughtsmen (age 30 to 38), experienced in the design of light and medium mechanical engineering products, for a vacancy in their Design Office at York.

This well established but rapidly growing member of a group of companies specialises in the manufacture of an original range of equipment for which it holds world patents and has an extensive programme of development in hand. In the field of Building and Civil Engineering the Company has supplied over 90 per cent of all portable bulk cement storage and handling equipment currently in use.

Applicants must be responsible men of good calibre, capable of taking charge of a design project from initial conception to the testing and development of prototypes for production. Preferably with some experience in structural design and holding H.N.C. (Mechanical).

This permanent position offers excellent staff conditions, progressive salary, bi-annual bonus and participation in non-contributory Pension Scheme. Residence in or near York is essential, assistance will be given with housing if required.

Written applications in confidence stating age, full details of training and experience and some indication of salary required should be addressed for the personal attention of:

Managing Director PORTASILO Limited Blue Bridge Lane, York E6849 A

SPERRY GYROSCOPE CO. LTD.

require

ELECTRICAL, ELECTRONIC & MECHANICAL
DESIGN & DEVELOPMENT ENGINEERS
DRAUGHTSMEN
DEVELOPMENT ASSISTANTS

for vacancies in the design and development of:

INDUSTRIAL PROCESS EQUIPMENT
MARINE NAVIGATIONAL AIDS & AUTO-PILOTS
AERO INSTRUMENTS & FLYING CONTROLS
GUIDED WEAPON COMPONENTS & CONTROL SYSTEMS

Applications, or requests for further information are invited from Engineers and Physicists with an Hons. Degree or equivalent for senior and intermediate level posts and those who have H.N.C. or O.N.C. for Assistant and Drawing Office Posts. The rewards are hard, interesting work and a good salary reviewed annually. Posts based at Brentford, Middx., and Bracknell, Berks., a new town where housing is available in approved cases.

Write in confidence to Mr. R. W. H. Lubbock, B.Sc., SPERRY GYROSCOPE CO. LTD., Bracknell, Berks. E6748 A

Large Midland Engineering Company

operating factories in the

BIRMINGHAM AND COVENTRY AREAS

have vacancies for capable young men 25/35, who have the experience and aptitude for

Ratefixing and Estimating

or

Time and Motion Study

Good commencing salary and future prospects. The posts also provide for successful applicants excellent opportunities for future promotion.

Applicants are requested to write in confidence, stating in full, age, education, technical qualifications, industrial experience, and any other details.—BOX No. E6879, "The Engineer."

A

SITUATIONS VACANT

DEVELOPMENT ENGINEER

Our Company, which occupies a leading position in the chocolate and confectionery industry, employs over 10,000 people in an extensive and well-equipped works on the outskirts of York. We have a large Engineering Division whose staff is constantly working on the development and installation of new machinery to meet the requirements of a highly-competitive industry, where a high standard of quality and efficiency are all-important. We have a vacancy for an Engineer with some experience of automatic machinery to join one of our research and development teams. The post will be concerned with the design, development and installation of automatic machinery for packing, wrapping, box-making and printing. Applicants, who must have a good technical education and preferably a university degree, should write for further details and our official application form to Staff Officer (Men), Rowntree & Co., Ltd., The Cocoa Works, York.

ROWNTREES OF YORK

E6830 A

HUMPHREYS & GLASGOW, LTD.

require

A PRODUCTION ENGINEER

A senior man of personality and drive with knowledge of shop practice in General Mechanical Engineering and Pressure Vessel Construction to take charge as Departmental Head of Inspection, Expediting, Progressing and Transport of purchased equipment. Staff about 35.

The salary paid will depend on ability and experience but will not be less than £2000.

Apply to :

Gordon Helps,
Joint Managing Director,
Humphreys & Glasgow, Ltd.,
22, Carlisle Place,
London, S.W.1. E6809 A

THE

GENERAL ELECTRIC COMPANY

LIMITED

ATOMIC ENERGY DIVISION

Applications are invited for the following appointments in the Division, for work on the design of complete Nuclear Power Stations :—

SENIOR MECHANICAL ENGINEERS

SENIOR ELECTRICAL ENGINEERS

Engineers of first-class ability with senior experience in conventional power station design are required. Broad experience is essential, but particular experience in any of the following will be an additional recommendation :—

Power system analysis and stability
Power system economics
Protection
Lighting
Hydraulic design of circulating water systems
Steam pipework design
Space heating and ventilating
Power station civil works
Power station operation

Applicants must be Chartered Mechanical or Electrical Engineers (and preference will be given to those who are both), and should have a good University Degree. Salaries will be commensurate with the responsibilities of these posts, which are considerable. Preferred age group 30–40.

Vacancies also exist for :—

JUNIOR MECHANICAL AND ELECTRICAL ENGINEERS

Experience in power station design work is not essential but applicants should have a good Engineering Degree and have served an apprenticeship. Some experience of heavy engineering, on outside erection, or on power station construction or operation, would be an advantage. Opportunities may subsequently occur to work on site, and to visit foreign countries. Age 23–30.

Apply to Personnel Manager (A.E.D.), The General Electric Company Limited, Erith, Kent. E6877 A

The Engineering Division of an international manufacturing company is seeking :

(1) SENIOR MECHANICAL ENGINEER

(2) ELECTRICAL ENGINEER

Both positions require fully qualified men with the ability, drive and personality to undertake considerable responsibility in a rapidly expanding organisation engaged in the building and development of new plants in Great Britain.

Attractive initial salaries will be offered, and full employee benefits include Company Pension and Life Assurance Schemes. In order to take full advantage of the opportunities offered, candidates should be in the 27–35 age group. Full personal details, with a summary of experience to date, should be sent to—BOX No. E6819, " The Engineer."

A

THE GENERAL ELECTRIC COMPANY LIMITED

have vacancy for an

OPERATING ENGINEER

for the Operational Service Department of their Turbine Division at Erith, Kent.

The post involves site investigations and applicants must have good all-round power station operating experience. Minimum qualification H.N.C.

Apply, giving age and experience, to Personnel Manager (T), The General Electric Company, Limited, Erith, Kent.

E6823 A

WELDING ENGINEERS

A large Company continuously engaged on major expansion projects has TWO interesting vacancies for Welding Engineers.

(1) WELDING ENGINEER FOR GENERAL WORKSHOP

The general workshop employs 1100 men of whom 45 are welders. The Welding Engineer will be required to control welding procedures and techniques and to establish and run a system of weld inspection. Materials such as mild, low alloy and stainless steels, aluminium and copper base alloys are used in component fabrication. Further development work on automatic and semi-automatic equipment requires to be done.

Applicants should have had considerable practical welding experience and have reached at least H.N.C. level, with suitable endorsements in metallurgy. An engineering Degree would be preferable.

(2) WELDING ENGINEER FOR CONSTRUCTION DEPARTMENT

The Welding Engineer will be responsible for the quality control of site welding on structures, pipe-work and vessels in aluminium and in mild and alloy steels erected by contract or by the Company's direct labour. He will assist in the development of appropriate welding techniques for new alloys, will maintain liaison with the Company's Metallurgical Department and will supervise the site welding inspectors.

Candidates must have been concerned with the practical application of welding, be accustomed to control of labour and have some metallurgical qualification as evidence of technical competence. The work is primarily in one area.

Starting salaries of up to £1300 p.a. are envisaged, dependent on age, qualifications and experience. The appointments are pensionable. The Company, which is a large one, is noted for its progressive staff policy and its welfare and social facilities.

Write, giving brief details of age, qualifications and experience, quoting reference W/P/8. to BOX No. E6762, "The Engineer." A

SITUATIONS WANTED

A TECHNICAL SALES ENGINEER, A.M.I. Mech.E. (40), first-class background, mature experience technical/commercial, fluency four languages, including Spanish, seeks change.—Please write BOX No. E1753, " The Engineer." B

FULLY QUALIFIED DIESEL MECHANIC (Swiss) seeks post as Contractors' Plant Mechanic or Excavator Driver or Garage Mechanic.—BOX No. E1808, " The Engineer." B

MECHANICAL ENGINEER, M.A. (Cantab), A.M.I.Mech.E. (37), single, experienced marine, power and nuclear design operation and contract administration, seeks position in S. England where initiative and advanced techniques can receive full scope. Willing to travel.—BOX No. E1806, " The Engineer." B

PRODUCTION ENGINEER (31), B.Sc. (Eng.), A.C.G.I., Inter. Cert. in Management Studies, seeks position, with prospects of increasing responsibility, in the field of Works Management. Experienced work study, plant layout, trouble shooting, &c.—BOX No. E1807, " The Engineer." B

BUSINESSES and PREMISES

ENTIRE SHARE CAPITAL in long-established North London LIGHT ENGINEERING BUSINESS with specialist product and full Order Book. Price £4500 as going concern, complete with valuable machinery.—GOOCH & WAGSTAFF, 3–4, Old Jewry, E.C.2 (MET 9444). E1794 L

AGENCIES

CANADIAN MANUFACTURERS' AGENTS, working with wholesale hardware and construction industry desirous Additional British Agencies. Representative in London for interviews April 22–25. —Reply, Rattray, Park Lane Hotel, London. E1801 D

ENGINEERS AND AGENTS well-established in London and South Eastern Counties, with sound export connection, require One or perhaps Two additional AGENCIES. Qualified and energetic team not afraid of a difficult task from Principals of repute if the long-term prospects are good and the product first-class.—BOX No. E6730, " The Engineer." D

DRAWING & DESIGN SERVICE

DRAWING AND DESIGN SERVICE.—Design and Development work required (London), for chemical and industrial plant equipment, special purpose machines, jigs and tools.—BOX No. E1720 " The Engineer" S

SUB-CONTRACTING

ACCURATE MACHINING

also on Models and Prototypes, &c.

MILLING TURNING
JIG BORING PLANING
PRESS TOOLS, JIGS AND FIXTURES
HORIZONTAL BORING

GIVE US YOUR DIFFICULT JOBS

LANDEN (ENGINEERS), LTD.
1A, AUBERT PARK, LONDON, N.5.
CANonbury 1075. E871 MW

CASTINGS.—We can save your porous castings, ferrous or non-ferrous, by an approved impregnation process ; sample castings treated ; A.I.D. approved. —Recupero, Ltd., 66, South Harrow Viaduct, Harrow, Middlesex ('Phone, Byron 1178). E575 MW

KELLERING and Profile Milling in all metals. Send us your die blocks to copy from wood or plaster masters. Up to 5ft. by 8ft. max. size. We are die copiers to the trade.—ARMYTAGE BROS. (KNOTTINGLEY), Ltd., The Foundry Knottingley, Yorkshire (Tel.: Knottingley 2743/4). E948 MW

PATTERN CAPACITY
WOOD AND METAL

Large modern pattern shop has Immediate Capacity Available for large Marine Type Patterns. Capacity is also Available for a wide range of other types of Pattern Equipment.—Universal Pattern and Precision Engineering Co., Ltd., Kelvin Way, Crawley, Sussex. E1802 MW

PRECISION ENGINEERS.—Personal service for prototypes, small quantity machined parts and equipments. Design and development undertaken. A.I.D. Approved.—Bowyer, Smyth and Partners, Ltd., Vineyard Walk, Clerkenwell, E.C.1 ('Phone, TERminus 5113/4). E650 MW

Follsain-Wycliffe

THE SPECIALIST FOUNDRY

The Specialist Foundry
with own machine shop
for
BLACKHEART MALLEABLE IRON CASTINGS
●
HEAT AND ABRASION RESISTING ALLOY CASTINGS
●
Manufacturers of the
'PULMAC' PULVERISING MILLS

FOLLSAIN-WYCLIFFE FOUNDRIES LTD.
LUTTERWORTH, Nr. RUGBY
Tel. 10, 60 & 152 E985 MW

FOR HIRE

LATTICE STEEL Erection Masts (light and heavy), 30ft. to 150ft. high, for immediate hire.—Bellman's, 21, Hobart House, Grosvenor Place, S.W.1 ('Phone, SLOane 5259). E112 K

PATENTS

THE PROPRIETORS of British Patent No. 721,924, for " Steam Generation and Compositions for Improving Steam Quality," desire to enter into negotiations with a firm or firms for the Sale of the Patent or for the grant of Licences thereunder.—Further particulars may be obtained from Marks and Clerk, 57 and 58, Lincoln's Inn Fields, London, W.C.2. E6846 H

MACHINERY Etc. WANTED

WANTED, Machines of all Types
CASH PAID.
Norman E. Potts (B'ham), Ltd., 130, Mossley Road, Birmingham 12. VIC. 1278 1279 1270, 0856. E123 F

WANTED, Tube Expanding Machine, Tube Cleaning Machine, 6in. to 8in. Screwing Machine, with collapsible head.—Fred Watkins (Boilers), Ltd., Coleford, Glos. E997 F

FOR SALE

METROPOLITAN-VICKERS 500 H.P. SLIP-RING ELECTRIC MOTOR, 196 r.p.m., 400/440/3/50 cycles, complete with control panel and reduction gearbox, giving a final speed of 8·1 r.p.m.
Motor and gearbox available separately if required.

JOHN CASHMORE, LTD.
Newport, Mon.
Tel.: Newport 66941 6 lines). E991 G

BL. HANGAR, 225ft. long by 120ft. clear span by 27ft. clear height. Excellent condition.—BOX No. E1796, " The Engineer." G

Classified Advts. continued on page 124

FOR SALE

BY ORDER OF THE MINISTER OF SUPPLY

SALE BY TENDER

MACHINE TOOLS

The Minister of Supply offers for SALE BY TENDER MACHINE TOOLS by leading British and Continental makers, including the following :—

Adcock and Shipley, Corona, Holroyd, Jones and Shipman, Leland Gifford and Pollard Drilling Machines.

Girard and G.S.P. Radial Drilling Machines.

Nova "A" Auto. Internal Grinders ; Churchill and Snow Surface Grinders ; Lumsden Wet Tool Grinder.

Edgwick and Fromag Keyseaters.

Herbert France and Fiat Capstan Lathes ; B.S.A. Multi Tool Lathes ; Gisholt Turret Lathe.

Adcock and Shipley, Sant Andrea, Werner, Edgwick and Sunstrand Horizontal Milling Machines.

Archdale, Biernatski, Brown and Sharpe, Herbert and Van Norman Vertical Milling Machines.

Pegard and Olivetti Production Milling Machines.

Hey Duplex Spline Milling Machines.

G.S.P. and Butler Slotting Machines.

Heller and Clifton & Baird Cold Saws.

Brinell Hardness Testing Machines.

Honing, Rifling, Screwing, Tapping and Reaming Machines, Thread Millers, Bench Grinders, Spot Welder, &c.

All the machine tools are lying at Dowlais, Glamorganshire.

Application for Tender forms should be made as soon as possible to the Ministry of Supply, Disposals 2(b), Room 621, First Avenue House, High Holborn, London, W.C.1.

Tender forms will contain descriptions of the machine tools, location in full, and the conditions of sale under which they are offered.

Offers are invited for single machines.

The final date for the receipt of Tenders will be 6th May, 1958. E6776

THE SOUTH OF SCOTLAND ELECTRICITY BOARD have the following SURPLUS PLANT FOR DISPOSAL :—

(a) Vertical Steam Boiler, Moir and Findlay (1903). No. 1495M, maximum working pressure 40 lb. sq. in.

(b) Vertical Steam Boiler, Clayton (1946), No. 7994, maximum working pressure 100 lb. sq. in.

(c) Hot Well Tank and electrically driven Feed Pump for item (b).

(d) 12 Unit Heaters (1948), for use with steam up to 100 lb. sq. in. (electrically driven fans).

(e) Steam Piping.

May be seen by arrangement at the Board's premises at High Street, Galashiels.—Sealed offers, endorsed "Tender for Surplus Plant," should be sent to the Secretary, Edinburgh and Borders Area, 52, Melville Street, Edinburgh, 3, not later than Monday, 12th May, 1958. E6866 G

NORTH WESTERN GAS BOARD LIVERPOOL GROUP

The Liverpool Group of the North Western Gas Board has for disposal a Geared Turbo-Alternator/D.C. Generator.

Makers : Turbine—Belliss & Morcom.
Gear Box—David Brown.
Alternator and Generator—Mather & Platt.

Capacity : Alternator—1250kW. M.C.R. at 400V., 50 c., 3 ph., 0·8 p.f.
Generator—300kW. M.C.R., 220/240V., D.C., mounted in tandem.

Steam Conditions : 167 lb. per sq. inch at 500 deg. Fah.
Complete with condenser, air pump, condensate pump and all fittings.

The whole plant was completely overhauled by the makers in 1948/49 and has never been used since. It can be inspected by appointment, on writing to W. S. Hubbard, Esq., M.I.Mech.E., M.Inst.Gas E., A.M.C.T., Production Engineer, North Western Gas Board, Liverpool Group, Radiant House, Bold Street, Liverpool, 1. E6750 G

NEW MITCHELL LATHE

for immediate delivery, 14½in. centre by 16ft. bed. Admit 9ft. 9in. between centres, hollow spindle, 4¼in. dia., swing 52in. dia. by 17in. wide in gap. NEW 16½in. CENTRE DITTO, 24ft. bed, to admit 17ft. 9in. between centres, 4¼in. hollow spindle, swing in gap 61in. by 18½in. wide.

F. J. EDWARDS LTD.,
359–361, EUSTON ROAD, LONDON, N.W.1.
EUSton 4681 and 3771. E6672 G

HYDRAULIC PRESSES

Large stock of modern Presses up to 10,000 tons capacity, for Forging, Forming, Extruding, Baling and other duties.

Enquiries from the Specialists :—
REED BROTHERS (ENGINEERING), LTD.,
Replant Works, Woolwich Industrial Estate, London, S.E.18.
Tel.: Woolwich 7611 (6 lines).
E6709 G

FOR SALE.—One DOBBIE McINNES Engine Indicator, Design No. 1 (large size), up to 250 r.p.m. and 225 lb. p.s.i.
Complete with Scales, Springs, &c., in polished hardwood box.
Very good condition. Any reasonable offer.—BOX No. E1793, "The Engineer." G

FOR SALE.—Hard Rolled Copper Sheets—6ft. by 3ft. and 8ft. by 4ft.—14 gauge, and 8ft. by 4ft.—12 gauge, mixed sizes in 16 and 14 gauge approx. 15 tons.—Thomas Dockrell, Sons & Co., Ltd. Dublin. E1795 G

FOR SALE

TWW

COLLET & ENGLEHARD FLOOR TYPE BORING MACHINE, 6·9in. spindle, traverse of spindle 64in., max. dist. spindle to base 148in., spindle speeds 1·5–200 r.p.m., movement of column on base 132in., column will swivel 360 deg., saddle swivel 50 deg., electrical equipment for 440V. D.C., with rectifier to operate from 400/3/50 cycles supply, baseplate 26ft. 3in. by 11ft. 10in., with outer steady.

BUTLER 24in. stroke OPENSIDE CRANK PLANING MACHINE, table working surface 48in. by 23in., with one toolbox on cross rail, max. dist. cross rail to table 21in., with 5 h.p. motor for 400/440/3/50 cycles supply.

TAYLOR & CHALLEN 1573B DOUBLE SIDED GEARED SINGLE CRANK POWER PRESS, 120 tons capacity, 18in. stroke, bed area 24in. by 26in., self-contained 15 h.p. motor drive, 400/3/50.

TAYLOR & CHALLEN 1562 DOUBLE SIDED GEARED SINGLE CRANK POWER PRESS, 200 tons capacity, 36in. stroke, bed area 24in. by 22½in., self-contained 30 h.p. motor drive, 400/3/50.

THOS. W. WARD LTD.
ALBION WORKS - - - SHEFFIELD
'Phone : 26311. 'Grams : "Forward."
E213 G

FRED WATKINS (BOILERS), LTD.

STEAM BOILERS.—Cochran Vertical (New), 8ft. 6in., 8ft., 7ft. 6in., 7ft. and 6ft. in dia., 100/150 lb. w.p.; reconditioned 8ft. 6in. down to 3ft. dia.; Economic, 4ft. to 11ft. 6in. dia., including new 7ft. and 8ft. dia., 150, 180 and 200 lb. w.p.; 300 reconditioned Vertical Crosstube, all sizes.

AIR COMPRESSORS.—Broomwade 510 cu. ft.; Tilghman 365 cu. ft.; Broomwade 300, 200 and 130 cu. ft.; all motorised.

200 AIR RECEIVERS, stocked up to 9ft. dia., 100 to 500 lb. pressure.

ELECTRIC MOTORS.—150 Totally Enclosed and Flameproof Motors up to 100 h.p.

CRANES.—Mobile 10-ton Lorain, lorry mounted, 30ft.–70ft. extendable jib; 4-ton Coles Diesel-Electric; 3-ton Jones Super 40 (3); Neals 2-ton Diesel, 20ft. jibs (2); Derrick, 5-ton Butters Electric travelling type, 90ft. jib; 5-ton Wilson Electric, 70ft. jib; 3-ton Rushworth Electric, 65ft. jib; Steam Loco., 18-ton Brownhoist, 50ft. jib; 10-ton Coles, 40ft. jib; 8-ton Wilson, 35ft. jib; 5-ton Smith, 50ft. jib; 5-ton Cowans Sheldon, 50ft. jib; 5-ton Grafton, 38ft. jib; E.O.T Goliath 40ft. span, 60-ton Clyde, 40-ton Babcock, 10-ton Morris; 10-ton Vaughan, unused, 40-60ft. span; 5-ton Henderson, 24ft. 7½in. span, 1946; 5-ton King 29ft. 3in. span; 2-ton Morris, 18ft. span 2-ton Smith, 34ft. span.

RAILWAY MATERIAL.—150 h.p. Stephenson Diesel Loco., fluid flywheel drive; Ruston 80/88 h.p. Diesel Loco. electric start, flameproof; Peckett 14in. by 22in. and 7in. by 12in. Steam Locos.; 3 miles 20 lb. Track, 24in. gauge bogies, turnouts locos., &c.

STEEL PIPING.—50,000ft., 2in. Galvanised new; 60,000ft., black new; 5000ft., 8in. seamless; 1000ft., 12in. seamless; 500ft., 14in. seamless; 400ft., 18in. riveted; 280ft., 21in. o.d. welded flanged; 3800ft., 21in. seamless flanged; 500ft., 24in. riveted; 1450ft., 27in. o.d. welded flanged; 216ft., 48in. riveted; 216ft., 60in. riveted.

CAST IRON PIPES.—Large stocks all sizes up to 24in. flanged and s.s. Immediate delivery.

VALVES.—Exceptional Surplus Ministry Lot New Stainless Acid Cocks and Valves, over 5000, immediate delivery, below makers' prices. Large stock, all sizes, Parallel Slide Sluice, Gunmetal, Reducing and Check Valves. List on request.

STORAGE TANKS.—300 cylindrical and rectangular up to 12,000 gallons, for oil and petrol, also sectional steel and cast iron up to 50,000 gallons.

MACHINE TOOLS.—Scriven Plate Bending Rolls, 14ft. by ¼in.; Robertson Straightening Rolls, 8ft. 6in. by ¼in.; Berry Bending Rolls, 7ft. by ¼in.; Tangye 300-ton Hydraulic Horizontal Straightening Press, 15ft. by 3ft. table; Herbert 3ND Miller, 61in. by 15in. table; Pels Punch and Shears, ¾in. capacity; nine new 2 cwt. and 1 cwt. Pneumatic Hammers.

SLING ENGINEERING WORKS,
COLEFORD, GLOS.
'Phone : Coleford 2271/2. E366 G

WERNER-PFLEIDERER MIXERS

ONE 5ft. 6in. by 4ft. 9in. by 2ft. 4in. Double Trough Jacketted Tilting Mixer, powered tilting, direct gear drive from 55 h.p. slipring motor, 400V/3 ph./50. New 1946.

ONE 2ft. 3in. by 1ft. 3in. by 1ft. 9in. deep Ditto. Bronze chamber and bronze mixing shafts and blades, hand tilting, vee rope drive through gearing.

BOTH EXCELLENT CONDITION.

DELIVERY : EX STOCK.

G. E. SIMM (MACHINERY) LIMITED,
27, BROOMGROVE ROAD,
SHEFFIELD, 10.
Telephone : 64436–7–8.
Telegrams : "Machinery."
E6831 G

VARIABLE SPEED UNITS Available from Stock, suitable for fitting to bench or pillar drills. Speed greatly increased and reduced, ratio 11 : 1. 5in. dia. size. £10 10s. Will give 16 separate speeds, which can be changed in ½ second. This Unit replaces Stepped Vee Pulleys and gear trains. This is the drive for machine tools of the future.—Send for details to-day.
PHILIP DE HAVILLAND MACHINE CO., LTD.,
64–66, Grosvenor Street, Portsmouth.
E1792 G

VOLTMETERS, AMMETERS, PRESSURE GAUGES.—Various petrol and oil tanks. Heavy duty petrol gauges, Vee and Flat Belting. Electric forge. Electric tyre inflators. 16ft. steel slings. Electric motors and generators. Ex. M.O.S.—Speed Electrics, Eastwood, Notts. E1739 G

FOR SALE

600

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Output/kW.	Pass-out/lb./hour	Lb. Pressure
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1800	40,000	110
1800	40,000	

double Pass/out at 1000kW., fully condensing.

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2.	14×22	040 Barclay	—	160	22
3.	14×22	040 Barclay	—	160	22
4.	14×22	040 Barclay	—	160	22
5.	14×22	040 Barclay	1935	160	22
6.	17×24	040 Bagnall	1934	160	36
7.	17×24	040 Bagnall	1940	160	36
8.	17×24	040 Bagnall	1941	160	36
9.	17×24	040 Bagnall	1941	160	36
10.	17×24	040 Bagnall	1944	160	36
11.	18×26	060 Bagnall	1950	180	40½

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1 Jones KL22 2-ton Mobile Crane, on pneumatics, 15ft. cantilever jib, Ruston diesel engine.
1 Coles 5-ton Mobile Crane, on pneumatics, cantilever jib, Perkins diesel engine.
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E211 G

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AUCTION PROGRAMME

		Main Location	*Auctioneers*
April 22	**Machine tools and miscellaneous stores,** including M/T spares, clothing, etc.	M.O.S. Storage Depot, **Ruddington, Notts.**	**WALKER, WALTON & HANSON** (Dept. L), Byard Lane, Bridlesmith Gate, Nottingham. (Tel.: 47271.)
April 29–May 1	**Vehicles and Miscellaneous stores,** including clothing, M/T spares, etc.	Central Ordnance Depot, **Bicester, Oxon.**	**MIDLAND MARTS, LTD.** (Dept. L), Market Square, Bicester, Oxon. (Tel.: 73.)
May 7–8	**Machine tools and miscellaneous stores,** including sewing machines, paint, etc.	Technical Stores Sub-Depot, **Old Dalby, Melton Mowbray, Leics.** (Sale at Melton Mowbray.)	**SHOULER & SON** (Dept. L), 1, Norman Street, Melton Mowbray, **Leics.** (Tel.: 81.)
May 12–16	**Vehicles and lifting equipment,** including :—	M.O.S. Storage Depot, **Ruddington, Notts.**	**WALKER, WALTON & HANSON** (Dept. L), Byard Lane, Bridlesmith Gate, Nottingham. (Tel.: 47271.)
	Passenger and load-carrying vehicles of most types, including saloons and estate cars, utilities, Jeeps and Landrovers, diesel-engined trucks, tankers and vans, low-loading plant trailers, mobile cranes, tractors, fitted workshops, motor cycles, etc.		
May 15	**Miscellaneous stores,** including furniture, etc.	General Stores Sub-Depot, **Longtown, Nr. Carlisle.** (Sale at County Hall, Carlisle.)	**HARRISON & HETHERINGTON, LTD.** (Dept. L), Botchergate, Carlisle. (Tel.: 26292/3.)
May 22	**Miscellaneous stores,** including tyres, engines, ball bearings, etc.	M.O.S. Storage Depot, **Rotherwas, Hereford.**	**RUSSELL, BALDWIN & BRIGHT, LTD.** (Dept. L), 20, King Street, Hereford. (Tel.: 4366.)

Catalogues (6d. each—P.O.'s. For sales after May 1st, 1s. 0d. each). Available *only* from the auctioneers shown above.

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E975 j

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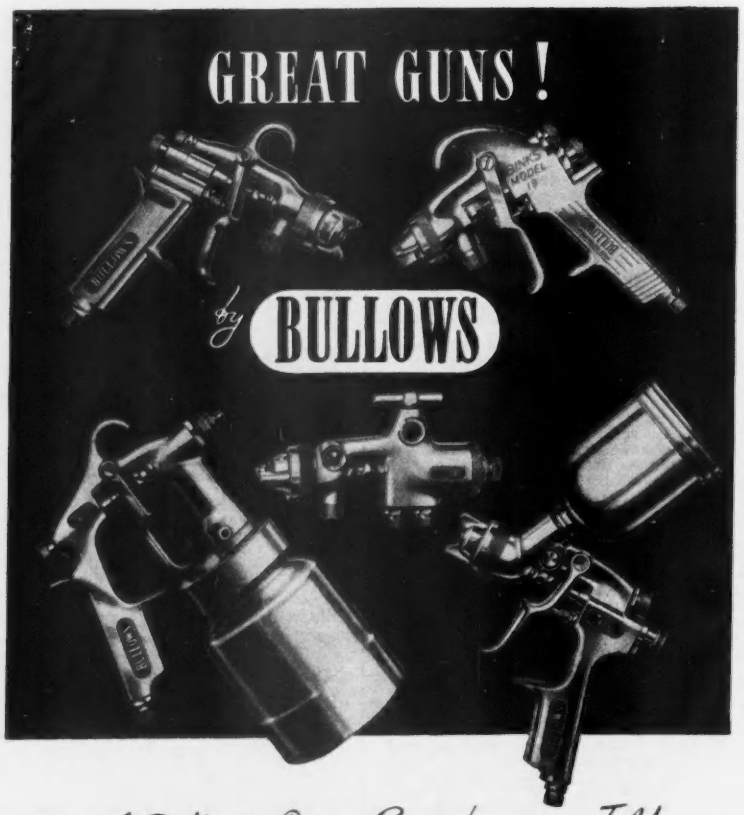

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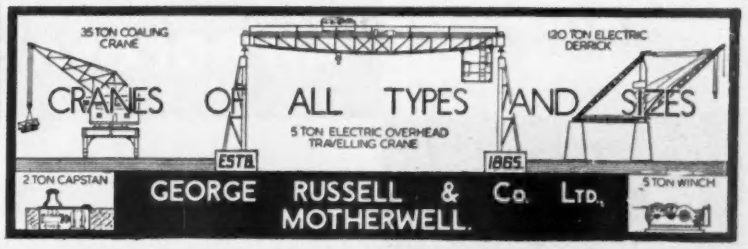

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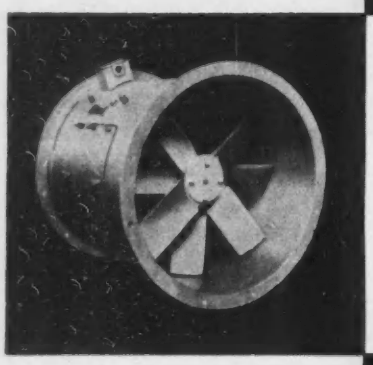

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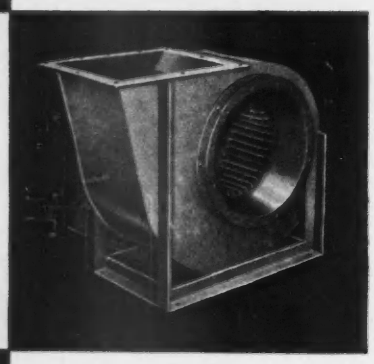

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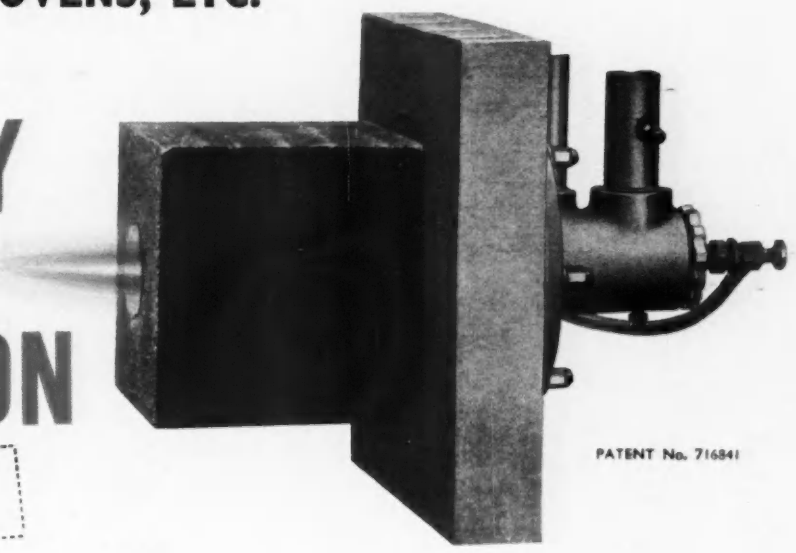

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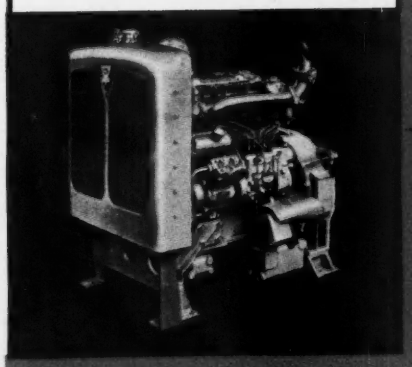

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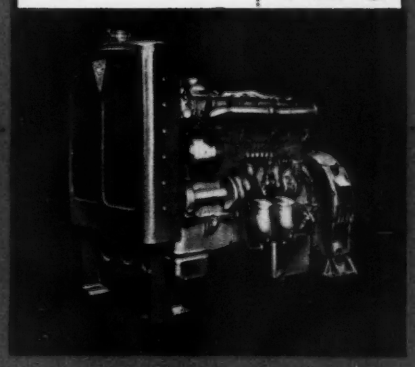

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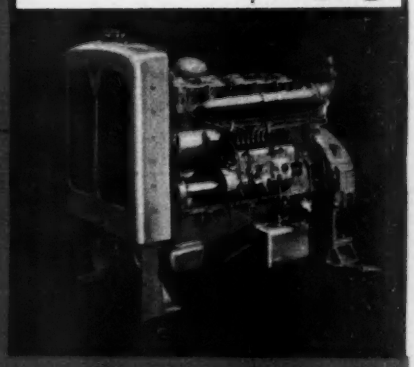

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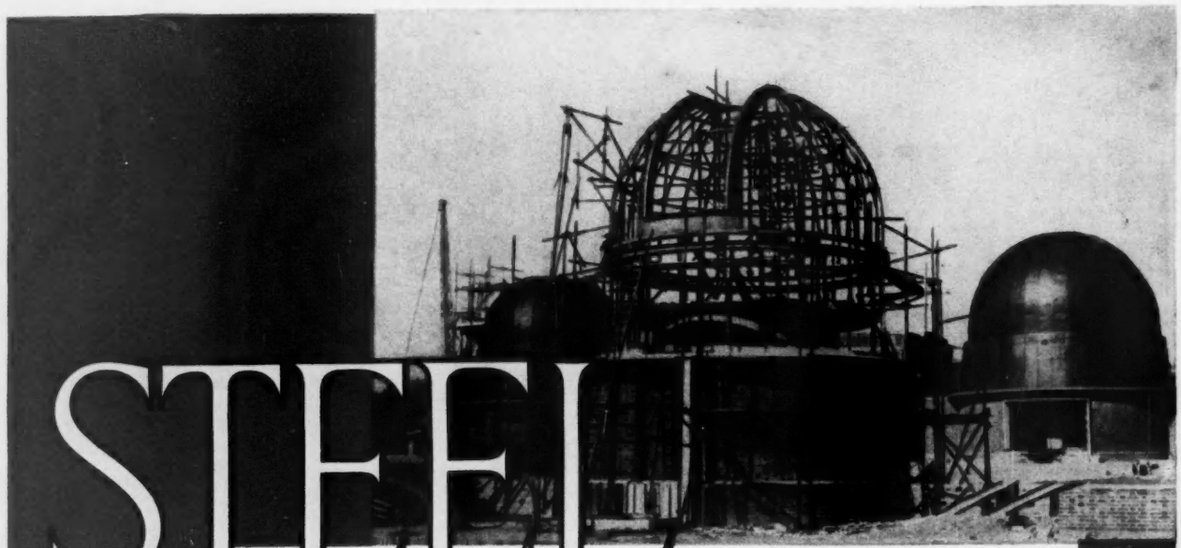

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